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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXIV.—No. 2972.] *LONDON: FRIDAY, DECEMBER* 15, 1922. [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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A. G. Mumford, Ltd., CULVER STREET WORKS, COLCHESTER. ON ADMIRALTY AND WAR OFFICE LISTS. ENGINES for Torpedo Boats, Yachts, Launches. BOILER FEED PUMPS. See advertisement pages 34 and 35, PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS. And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant OF ALL DESCRIPTIONS. FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND. Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C. 2. *See half-page Advert. last week and next week.* 675

Cranes.—Electric, Steam, HYDRAULIC and HAND, of all types and sizes. GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 9048

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited, BIRMINGHAM. 7411 See Advertisement last week, page 91.

Spencer-Hopwood & Kirke PATENT BOILERS. 877 *See page 80.* Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives. Specification and Workmanship equal to Main Line Locomotives. R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 9044

Cochran Boilers. MULTITUBULAR AND CROSS-TUBE TYPES. See page 17. 9047

E. J. Davis, M.I.Mech.E., Gas Engines Inspected, Tested and Reported Upon. Over 20 years' experience. Tel.: 735 and 737 Stratford. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E. 15. 1794

Brett's Patent Lifter Co. LIMITED. Hammers, Presses, Furnaces, COVENTRY. 610

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd., Newton Heath Glass Works, Manchester. Od 9753

Electric Cranes.
S. H. HEYWOOD & CO., LTD., RHDDISH. 9862

Fuller, Horsey, Sons & Cassell. SPECIALISTS in the SALE AND VALUATION of PLANT AND MACHINERY and ENGINEERING WORKS. 11, BILLITER SQUARE, E.C.3. 1834

Iron and Steel
Tubes and Fittings. Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817
The Scottish Tube Co., Ltd., HEAD OFFICE: 34, Robertson Street, Glasgow. See Advertisement page 71, Dec. 8.

YARROW & CO. (1922), LTD., GLASGOW.
PASSENGER AND CARGO STEAMERS, SHALLOW DRAFT VESSELS. 818

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 13 ft. diam. Bevel and Mitre Wheels planed up to 3 ft. diam. Spur Wheels cut up to 9 ft. diam. DOLPHIN FOUNDRY, LEEDS. 4547

VOSPER & CO., LTD., PORTSMOUTH. SHIP & LAUNCH BUILDERS, Od 3261 ENGINEERS & BOILER MAKERS.

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OIL FUEL APPLIANCES, *Systems* PRESSURE, AIR, STEAM *For Boilers of all types.* KERMODES LIMITED, 35, The Temple, Dale Street, Liverpool. *Naval Outfits a Speciality,* also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds. Supplied to the British and other Governments. Telephone No.: Central 2832. Telegrams: "Warmth." 4078

Locomotives Tank Engines designed and constructed by MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od 9487 See their Illus. Advertisement, page 93, last week.

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd. THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

R. Y. Pickering & Co., Ltd., (ESTABLISHED 1864.) BUILDERS of RAILWAY CARRIAGES & WAGONS. MAKERS of WHEELS and AXLES of all kinds. RAILWAY WAGONS FOR HIRE. Chief Works and Offices: WISHAW, near GLASGOW. London Office: Od 8353 2, VICTORIA STREET, WESTMINSTER, S.W.

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Electric Transporters.
S. H. HEYWOOD & CO., LTD., RHDDISH. 9862

John H. Wilson & Co., Ltd., Birkenhead.
See Illustrated Advertisement Page 87, Dec. 8.

Locomotive Shunting Cranes

Steam and Electric Cranes EXCAVATORS, CRANE-BAVVIES, GRABS, CONCRETE-MIXERS. SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY. 627
LISTS OF STANDARD SIZES ON APPLICATION.
London Office: 15, VICTORIA STREET, S.W. 1.

John Bellamy, Limited, MILLWALL, LONDON, E. 1916 GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

IRON & STEEL
Tubes AND Fittings AND **Steel Plates.**
STEWARTS AND LLOYDS, Ltd. GLASGOW - BIRMINGHAM - LONDON. See Advertisement Page 82. 9952

Economy!
HIGH BOILER EFFICIENCIES ARE OBTAINED BY INSTALLING
Todd Oil Burners FUEL OIL BURNING SYSTEMS, HEATERS, STRAINERS. 49-51, EASTCHEAP, LONDON, E.C. 3.
TODD SHIPYARDS CORPORATION, Builders of Steam and Motor Ships, Repairers, Electric Drive Installations. Twenty-one Floating Docks, Two Graving Docks, Twelve Shipways. 25, Broadway, New York, U.S.A. 9940

The Glasgow Railway Engineering Company, GOVAN, GLASGOW. LTD., London Office—12, Victoria Street, S.W. MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES. CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 840

SPECIFY WELDLESS STEEL CHAIN.
The Strongest Chain IN THE WORLD. 998 Sole Manufacturers: WELDLESS CHAINS, LTD., 50, WELLINGTON STREET, GLASGOW.

ON ADMIRALTY LIST.
John Kirkaldy, Ltd., London Office: 101, LEADENHALL ST., E.C. 3. Works: BURNT MILL, near HARLOW, ESSEX. Makers of Evaporating and Distilling Plants. Refrigerating and Ice-Making Machinery. Feed Water Heaters. Evaporators. Fresh Water Distillers. Main Feed Pumps. Combined Circulating and Air Pumps. Auxiliary Surface Condensers, &c. &c. 846

Electric Lifts (UP TO 35 TONS.)
S. H. HEYWOOD & CO., LTD., RHDDISH. 9862

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd., Builders of RAILWAY CARRIAGES, WAGONS, ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK. Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS, PRESSED STEEL WORK OF ALL KINDS. Registered Office and Chief Works: Motherwell. London Office: 14, Leadenhall Street, E.C. Od3383

Liquid Air, and all other Gases. Second-hand ELECTRICALLY DRIVEN COMPRESSORS for pressures up to 2000 lbs. per sq. in MOTORS 60 to 100 HP. In perfect condition, at about one-third current prices. Also DIESEL Engines to 1200 HP. CENTRIFUGAL and other PUMPS, and D.C. MOTORS, 200/250 volts, from 4 to 600 HP.
JENNINGS, West Walls, Newcastle-on-Tyne. 978

Royles Limited, ENGINEERS, IRLAM, MANCHESTER. FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS. } Rowe's PATENTS. Merrill's Patent TWIN STRAINERS for Pump Suctions. SYPHONIA STEAM TRAPS, REDUCING VALVES High-class GUNMETAL STEAM FITTINGS. WATER SOFTENING and FILTERING. 8726

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS. 819

Matthew Paul & Co., Ltd. LAWRENCE WORKS, Dumbarton. 769 See Full Page Advt., page 64, Dec. 8.

Forgings.
Walter Somers, Limited, HALESOWEN. 7116

Taylor & Challen Presses For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER. Foundry, Works, and Showrooms: BIRMINGHAM. See half page advert., page 86, Dec. 8. 8193

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS. Forgings, Castings, Bars, Sheets, Wire, Tubes. THE DELTA METAL CO., LTD., 631 E. GREENWICH, LONDON, S.E. 10 (& at Birmingham)

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 600

'Phone—Holb. 541. Tele.—Andrubo, Holb., London.
Andrews & Beaumont, CHARTERED PATENT AGENTS, 976 29, Southampton Buildings, London, W.C. 2.

Rosser and Russell, Ltd., MECHANICAL ENGINEERS, QUEEN'S WHARF, HAMMERSMITH, W. Undertake SPECIAL MACHINE WORK of any description. WELL EQUIPPED SHOP. LATHE WORK up to 10 ft. diameter. *Phone:* Hammersmith 31, 907. 9211

Locomotive Traversers (ELECTRIC).
S. H. HEYWOOD & CO., LTD., RHDDISH. 9862

P. & W. MacLellan, Ltd., CLUTHA WORKS, GLASGOW. MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION. RAILWAY IRONWORK, BRIDGES, ROOFING, &c. Chief Offices: 120, Trongate, Glasgow. Od 3547 Registered Offices: Clutha House, 10, Princes St., Westminster, S.W. 1.

Centrifugals.
Pott, Cassels & Williamson, MOTHERWELL, SCOTLAND. 939 See half-page Advertisement, page 66, Nov. 24.

The Manchester Steam Users' ASSOCIATION.
For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. H. STROMEYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 598

All Engineering Exams.
Director of Engineering: J. WHITE, B.Sc. (Eng.), Hons. Lond. Expert Postal or Private TUITION in ALL ENGINEERING SUBJECTS, for B.Sc., Inst.C.E. and Mech. E. Special courses in SURVEYING, Draughtsmanship, GEOLOGY, Chemistry, FUEL TECHNOLOGY and MINING courses. Write for Prospectus to the PRINCIPAL: J. W. FARMERY, M.A. (Cantab.), Dept. EN, 39, Victoria St., Westminster, S.W. 1.
Tel.:—Victoria 4411. W 826

Inst. C.E., I. Mech. E., B.Sc., and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., M.E.E., A.M.Inst.C.E., F.S.I., M.E.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 1030

Correspondence Courses for Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 6/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 876

Correspondence Courses for INST MECH. E. EXAMINATIONS. — Also Special Courses as follows: Works Organisation, Administration, Pneumatic Engineering, Crane Design, &c.—Address, W 927, Offices of ENGINEERING.

All Engineering Exams.— Personal & successful preparation by B.Sc. (Eng)—46 Denison House, Vauxhall Bridge Road (3 min. from Victoria Station). Tel 7045 Victoria W 994

A Brochure on "Engineering SALESMANSHIP and SALES MANAGEMENT," with particulars of a SPECIAL COURSE of training, will be sent post free on application to DIRECTOR, THE INSTITUTE OF ENGINEERING SALESMANSHIP, 538, Oxford Rd., Manchester. 985

Powering of Vessels.—A Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 1049, Offices of ENGINEERING.

TENDERS.

MIDLAND GREAT WESTERN RAILWAY OF IRELAND COMPANY.

STEEL RAILS AND FISHPLATES.

The Directors of the above Company are prepared to receive

Tenders for the Supply of 3000 TONS of STEEL RAILS and corresponding Fishplates.

Specification, giving all particulars, can be had on application to the undersigned.

Tenders, sealed and endorsed "Tender for Rails," to be forwarded addressed to the Chairman, Midland Great Western Railway, Broadstone Terminus, Dublin, so as to reach him not later than Monday, 1st January, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

PERCY A. HAY,
Secretary.

Broadstone Terminus, Dublin.
8th December, 1922. X 59

CHEADLE AND GATLEY URBAN DISTRICT COUNCIL.

ELECTRICITY SCHEME.

The Cheadle and Gatley Urban District Council invite

Tenders for :—
SUB-STATION SWITCHGEAR CONTRACT No. 2
STATIC TRANSFORMERS CONTRACT No. 3.

Copies of Specifications with Forms of Tender, General Conditions and Drawings can be obtained from Mr. C. H. WORDINGHAM, C.B.E., M.Inst.C.E., M.Inst.E.E., either at 7, Victoria Street, Westminster, S.W. 1, or 11, Mosley Street, Manchester.

A deposit of Three Guineas (Contract No. 2) and One Guinea (Contract No. 3) is required which will be returnable provided that a *bona fide* tender be submitted and not withdrawn. Duplicate Specifications will be supplied on payment of One Guinea (Contract No. 2) and Half-a-Guinea (Contract No. 3) per copy, which sums are not returnable. All cheques to be made payable to the Engineer.

Tenders, enclosed in envelope, sealed with wax and clearly endorsed "Tender for Sub-Station Switchgear" and "Tender for Static Transformer" respectively, must be addressed to the undersigned at the Council Offices, Cheadle, Cheshire, and be delivered not later than Ten a.m. on Monday, 1st January, 1923.

The Council does not bind itself to accept the lowest or any Tender.

By Order,
JOHN H. JOHNSON,
Clerk to the Council.

Council Offices,
Cheadle, Cheshire.
7th December, 1922. X 65

MANCHESTER CORPORATION WATERWORKS.

THIRLMERE AQUEDUCT: FOURTH PIPE LINE.

NORTH AND SOUTH WELL VALVES, ETC.

The Waterworks Committee invite

Tenders for the Supply and FIXING of 86 in. SELF-ACTING CYLINDER VALVES, 64 in. and 56 in. MANUAL CYLINDER VALVES, 56 in. and 48 in. OUTLET VALVES, etc.

Specification, Form of Tender, etc., may be obtained on application to the Secretary, Waterworks Offices, Town Hall, Manchester, upon payment of a deposit of Five Guineas, which will only be returned to the Tenderer provided that he shall have sent in a *bona fide* Tender, and shall have returned the documents and the drawings lent to him, the drawings to be unmarked. Further information, if required, may be obtained from the Waterworks Engineer.

Sealed Tenders, endorsed as directed, must be delivered at the Waterworks Offices, Town Hall, Manchester, not later than the 20th January, 1923.

By Order,
P. M. HEATH, Town Clerk.

Town Hall, Manchester.
14th December, 1922. X 106

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of :—
1. STEEL RAILS and FISHPLATES.
2. SPARE PARTS for Locomotive Engines.
3. COPPER TUBES, BRASS SHEETS, etc.
4. INDIA RUBBER GOODS.
5. STEEL WORK for Bridges, Tinnevelly-Tiruchendur Railway.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tender for Steel Rails and Fishplates," or as the case may be, must be left with the undersigned not later than Twelve noon on Friday, the 29th December, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of £1 for each copy of the Specifications Nos. 1 and 2, and of 10s. for each copy of Specifications Nos. 3, 4 and 5.

Copies of the Drawings may be obtained at the Offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W. 1,
12th December, 1922. X 104

URBAN DISTRICT COUNCIL OF WINDLESHAM (SURREY).

NEW SEWERAGE & SEWAGE DISPOSAL SCHEME FOR BAGSHOT, LIGHTWATER AND WINDLESHAM.

UNEMPLOYMENT RELIEF WORKS.

TO CAST-IRON PIPE FOUNDERS.

The Urban District Council of Windlesham (Surrey), invite

Tenders for the Supply and DELIVERY at Bagshot of about 330 tons, more or less, of CAST-IRON PIPES, varying in size from 2½ in. to 15 in. internal diameter; also a number of BENDS, TAPER JUNCTIONS and other Specials.

A copy of the Specification and Form of Tender may be obtained on application in writing to Major T. J. MOSS-FLOWER, Civil Engineer, 25, Victoria Street, Westminster, S.W. 1, and Carlton Chambers, Bristol, at his Bristol office, on and after 16th December, 1922, on payment of the sum of Three Guineas, which will be returned, provided a *bona fide* tender be received and is not withdrawn before the acceptance by the Council of one of the Tenders.

Sealed Tenders endorsed "Tender for Cast-Iron Pipes," are to be delivered at my office at Bagshot, by Four p.m. on 29th December, 1922.

The lowest or any Tender will not necessarily be accepted.

Dated this 9th day of December, 1922.

By Order,
EDWYN T. CLOSE,
Solicitor & Clerk to the Council.

Council Offices,
Bagshot, Surrey. X 98

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification may be obtained or inspected upon application to:—
AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C. 2.
SPECIFICATION No. 22/6—
ASH AND DUST EXTRACTION PLANT.
CHARGE:—£2 2s. for the first two copies of Tender Form, Conditions of Contract and Specification complete. This charge will be returned on receipt of a *bona fide* Tender. A third or any further copies will be supplied for the sum of £1 1s. each, not returnable.

PRELIMINARY DEPOSIT:—A Preliminary Deposit of £50 is required to be lodged with Tender.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m. on March 7th, 1923.

R. LIDDELOW,
Secretary.

State Electricity Commission of Victoria,
Melbourne,
Australia. X 85

BENGAL-NAGPUR RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for :—
35 TON ELECTRIC TRAVERSER.

Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C. 2, on or after 11th December, 1922.

A fee of 10s. 6d. will be charged for the specification, which will not be returned.

Tenders must be submitted not later than Noon on Friday, 22nd December, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
R. C. VOLKERS, Secretary. X 75

BENGAL-NAGPUR RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for :—
THREE 10 TON STEAM TRAVELLING CRANES.

Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C. 2, on or after 13th December, 1922.

A fee of £1 1s. will be charged for the specification, which will not be returned.

Tenders must be submitted not later than Noon on Friday, 22nd December, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
R. C. VOLKERS,
Secretary. X 93

COUNTY BOROUGH OF PRESTON.

ELECTRICITY UNDERTAKING.

COAL AND ASH HANDLING PLANT.—R.P.S.S.

The Corporation invite

Tenders for the Supply, DELIVERY, ERECTION, and COMPLETION of COAL and ASH-HANDLING PLANT for the Ribble Power Station.

Specifications, Drawings, and Form of Tender, may be obtained on application to the Town Clerk, Town Hall, Preston, on and after the 12th instant, on payment of a fee of £2 2 0 which will be refunded upon receipt of a *bona fide* Tender.

Additional copies of the Specification may be obtained from J. A. ROBERTSON, Consulting Engineer, Brazennose House, 30, Brazennose Street, Manchester, upon payment of 10s. 6d. (which payment is not returnable)

Sealed Tenders, endorsed "Coal and Ash-Handling Plant," and addressed to the undersigned, shall be delivered at the Town Hall, Preston, not later than Twelve noon on Wednesday, January 10th, 1923.

The Corporation do not bind themselves to accept the lowest or any Tender.

ALFRED HOWARTH,
Town Clerk.

Town Hall,
Preston. X 63

THE BENGAL AND NORTH WESTERN RAILWAY CO., LTD.

The Directors are prepared to receive

Tenders for the Supply of—
30 BOGIE CARRIAGES (28 3rd Class and Two composite 1st and 2nd Class)
as per specification to be seen at the Company's Offices.

Tenders, addressed to the undersigned, and marked "Tender for Carriages," are to be lodged not later than Noon on Monday, the 15th day of January, 1923.

For each specification a fee of £1 will be charged, which cannot, under any circumstance, be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
E. A. NEVILLE,
Managing Director.

237, Gresham House, Old Broad Street,
London, E.C. 2.
12th December, 1922. X 108

APPOINTMENTS OPEN.

UNIVERSITY OF CAPE TOWN.

CIVIL ENGINEERING DEPARTMENT.

ASSISTANT AND DEMONSTRATOR.

Applications are Invited for the POST of FIRST GRADE ASSISTANT and DEMONSTRATOR in the Civil Engineering Department of the University of Cape Town. Salary £320 rising by £25 per annum to a maximum of £450. An allowance of £40 will be made for passage money.

The duties of the post will include taking tutorial classes, assisting with the structural and design classes, preparing drawings, diagrams and cartoons, taking practical surveying and generally carrying out the instructions of the head of the department. Applicants should have a good theoretical knowledge of engineering and be good draughtsmen and surveyors, and it is also desirable that they should have had some practical experience.

The successful applicant will be required to become a member of the University Teachers Superannuation Fund and to take up his duties by 1st March, 1923.

Applications and copies of testimonials, all in duplicate, should reach the SECRETARY, Office of the HIGH COMMISSIONER for the UNION OF SOUTH AFRICA, Trafalgar Square, W.C., from whom Forms of Application may be obtained, not later than the 31st December, 1922. X 73

The Chatwood Safe Co., Ltd., Bunkers' Engineers, Bolton, desire to advise all applicants for the position of Assistant to the Technical Director recently advertised, that the appointment has been made.

As the applications were rather overwhelming they find it impossible to extend the courtesy of a personal reply. X 64

Assistant Required for Ad- vertising Department of large Firm of Electrical Engineers and Manufacturers. Previous advertising experience and technical engineering knowledge essential. State age, experience and salary required.—Address, X 69, Offices of ENGINEERING.

A Capable Works Manager REQUIRED for non-ferrous sheet metal works in East. Must be competent Engineer, Toolmaker, Draughtsman, familiar with modern costing methods and capable of handling native labour. Good prospects for right man. State age (not over 39), qualifications and remuneration expected.—Address, X 52, Offices of ENGINEERING.

Works Manager Wanted.— Engineer, with organizing ability, initiative, energy and tact, required to take charge of old-established Gas Meter manufactory employing about 300 hands.—Apply, by letter, stating experience, what references can be given, and what salary required to BOX 2377, WILLINGS, 30, King Street, Covent Garden, W.C. 2. X 100

Purchasing Department.— One of the largest Engineering and Steel Manufacturing Concerns in the country REQUIRE the services of a real live
ENERGETIC GENTLEMAN,
full of initiative, to take charge of and re-organise their Purchasing Department.

Applicants must be between 35 and 50 years of age, have had a thorough training in such work, and be of unimpeachable character. They must have previously held a position of responsibility in a leading similar concern, or in the Stores Department of any of the leading Railway Companies.

All applications will be treated in the strictest confidence; copies only of references to be sent.

Applicants must state where their experience has been gained, whether they are fully conversant with the best markets to place business for engineering as well as shipbuilding requirements, and what responsible official of the concern they are with is prepared to recommend them.—Address, W 998, Offices of ENGINEERING.

Required, the Services of a thoroughly Competent CLERK OF WORKS, for a period of about 18 months, at an inclusive salary of £400 per annum, to superintend the construction—in the South of England—of a Sand Filter Bed, about half-an-acre in area, Covered Service Reservoir with re-inforced concrete roof, to hold about 2½ million gallons, and Incidental Works. Applications, which must be delivered not later than the 1st January, 1923, must be made on a special form provided for the purpose which will be forwarded upon application. — Address, X 79, Offices of ENGINEERING.

THE WINDLESHAM URBAN DISTRICT COUNCIL, SURREY.

BAGSHOT, LIGHTWATER & WINDLESHAM SEWERAGE & SEWAGE DISPOSAL WORKS.

CLERK OF WORKS.
(To commence duties at an early date).

The Council invite

Applications for the above APPOINTMENT. Candidates must be thoroughly experienced in the construction of Modern Sewage Disposal and Drainage Works, and be able to efficiently discharge the duties required of Clerk of Works on works of this kind, and must be competent with the use of the Level and Theodolite, and be able to Set Out and Measure Up Works, and keep Accounts, etc.

No others need apply.

Preference will be given to qualified Ex-Service Men.

The Clerk of Works will be required to act under the direction of Major T. J. MOSS-FLOWER, the Council's Consulting Engineer, and to devote the whole of his time to the duties of his office.

Salary £3 per week.

Time about 18 months subject to approved service, and the engagement to be terminable by a month's notice on either side.

Applications marked "Clerk of Works," stating previous experience and enclosing copies of three recent testimonials to be sent direct to the Engineer, at his Bristol Office, Carlton Chambers, Baldwin Street, Bristol, so as to reach him not later than Noon on Thursday, December 28th, 1922.

By Order,
EDWYN T. CLOSE,
Solicitor and Clerk to the Council.

Council Offices, Bagshot, Surrey,
9th December, 1922. X 81

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THE DETERMINATION OF THE CALORIFIC VALUE OF LIQUID FUELS.

By H. MOSS, D.Sc., A.R.C.S., D.I.C., and W. J. STERN, B.Sc., A.R.C.S., D.I.C., Air Ministry Laboratory, Imperial College of Science and Technology.

I. *Introduction.*—The usual method for the determination of the calorific value of liquid fuels is that of the bomb calorimeter. Although accurate comparisons of the values for different fuels may be found by the method, the absolute values are not obtained with the same certainty. The water equivalent of the apparatus which has to be added to the weight of water used, is about 25 per cent. of the total water equivalent, and is usually found by calibrating the calorimeter with some fuel whose calorific value is assumed. Experiments on other fuels have then to be made under very similar conditions of amount of water and temperature rise as obtained during the calibration. The amount of fuel which can be used and which has to be weighed and afterwards transferred to the bomb, is only about 1 gramme. The present experiments were undertaken in order to investigate methods of determining calorific values, with a view to evolving one by means of which the absolute values for any fuel undergoing engine tests could be obtained quickly and accurately.

A method of obtaining a constant small flow of fuel, vaporising it, burning the vapour in a bunsen burner and determining the calorific value by means of the Boys' gas calorimeter, was published by Professor W. Watson, of the Imperial College of Science, in 1909 (Proceedings of the Institution of Automobile Engineers, Vol. iii). This apparatus was reconstructed and certain improvements made in it. A second method of great simplicity was then suggested by Professor Callendar, in which the Boys' gas calorimeter was also used, but the fuel was burnt in a stove of the Primus type suspended from the arm of a balance, and the quantity burnt in a given time obtained by the loss in weight of the stove and contents. A preliminary series of experiments showed that the method promised to give the required accuracy and ease of manipulation, but the Primus burners that were available were of unsuitable shape and size for the chimney of the Boys' calorimeter, and complete combustion was not obtained. Investigations were proceeding on the size and shape of the burner when it was learnt that the method had been fully developed in Germany in conjunction with the Junkers' gas calorimeter. A complete apparatus consisting of calorimeter, stove and balance was purchased by Professor Callendar for the Imperial College of Science (who also owned the Boys' calorimeter and the Watson vaporiser), and a thorough investigation of its capabilities was made. Experiments were made with aviation petrol, benzene, absolute alcohol and paraffin oil at various rates of burning and with different water flows. The heat losses were examined and the accuracy of the instrument determined.

II. *Results.*—The Watson vaporiser as improved, and regulated so as to give a flow that was completely burned, was found to give accurate and consistent results, and necessitated less continuous manipulation than in the original form, but it still requires considerable skill and care in order to ensure this accuracy. It forms a convenient method, however, where a gas calorimeter is available and the balance method is not. The balance method was found to be extremely simple and easy to manipulate, and gave very accurate and consistent results without any necessity for extreme care. For different kinds of fuel it is necessary to use different burners and rates of burning, in order to ensure complete combustion and steady flame, but within wide limits a single determination of the calorific value should give a result correct to 0·5 per cent. The correction necessary for radiation loss is usually less than 1 per cent., and there is no correction for the water equivalent of the apparatus if steady conditions of fuel consumption and water flow are maintained. No correction is necessary for the heat required to vaporise the fuel and to heat the accompanying air, as is the case with the Watson vaporiser, for the heat is supplied by the fuel itself in the Primus burner. The method is also to be preferred to that of the Watson vaporiser in that the fuel consumed is obtained by weight instead of by volume, while the Junkers' calorimeter takes up a steady temperature distribution in much less time than the Boys' calorimeter. The time required to set up the apparatus, obtain steady temperature conditions, take two determinations burning 10 grammes of fuel in each, and obtain the two results, is not more than 30 minutes. The method can be recommended without reserve for quick and accurate determinations and for ease and simplicity of manipulation.

III. *Watson Vaporiser.*—The arrangement of the Watson vaporiser is shown diagrammatically in Fig. 1 in conjunction with a Boys' calorimeter. It can, of course, be used with the Junkers' or any other form of calorimeter. The fuel is delivered at a constant rate at the jet A, and in falling it strikes a number of discs of wire gauze placed in the brass tube B. This tube is surrounded by a steam jacket and a gentle but steady stream of air is passed through it. The air is so regulated that all the fuel is vaporised and carried through to the Bunsen burner E. If the supply of fuel is too great so that complete vaporisation does not take place, the excess of liquid collects in the test tube C. The jet A must be so shaped that the fuel is delivered as a fine spray rather than a succession of drops, in order to obtain a regular air-fuel mixture. The amount of fuel burned per minute should be within limits similar to those indicated in the next section on the balance method, in order that complete combustion should take place. The hot gases formed by the combustion circulate in the calorimeter F, and part with their heat to water which is passed at a constant rate through coils of tube. The rate of flow of water can be altered by change of head. The temperature of the water is noted where it enters and leaves the calorimeter, and from the temperature rise and the volume of water passing in a given time, the heat developed by the combustion can be calculated.

To obtain a constant flow of fuel a constant head is maintained which causes the fuel to flow through the capillary tube H G, which is water-jacketed to maintain the temperature constant. While making preliminary adjustments, and waiting till the rise in temperature of the water flowing through the calorimeter is constant, the fuel is supplied from the bulb M, the tube L serving to keep the head constant. When the test is to be started the tap K is turned so that the fuel is delivered from the bulb N, the air to take the place of the fuel that flows out of the bulb entering through the capillary O. In this way the head causing the flow is always equal to the vertical distance of the lower end of the capillary above the jet A. The upper end of the capillary is connected to the tube surrounding A in order to ensure equality of air pressure at these two points whatever changes there may be due to the air flow through B and past A. The side tube and tap Q serve to remove any bubbles of air when filling the apparatus, while the tap P at the lowest point serves for emptying and filling. One mark above the bulb N and another below indicate a known volume of fuel, the heat developed by the consumption of this volume being measured by the calorimeter. Any water condensed in the calorimeter from the hot gases is collected and measured, and the heat given up by its condensation, and cooling is subtracted in order to obtain the lower calorific value.

A certain amount of heat has been supplied in order to vaporise the petrol and to heat the air stream passing through B to the temperature of steam. This correction is appreciable, though not very large, and an approximation to its value was only obtained. The specific and latent heat of petrol are known, but the quantity of air was only estimated at six times that of the petrol. The remaining air for complete combustion mixes

Fig. 1.

WATSON VAPORISER WITH BOYS' CALORIMETER.

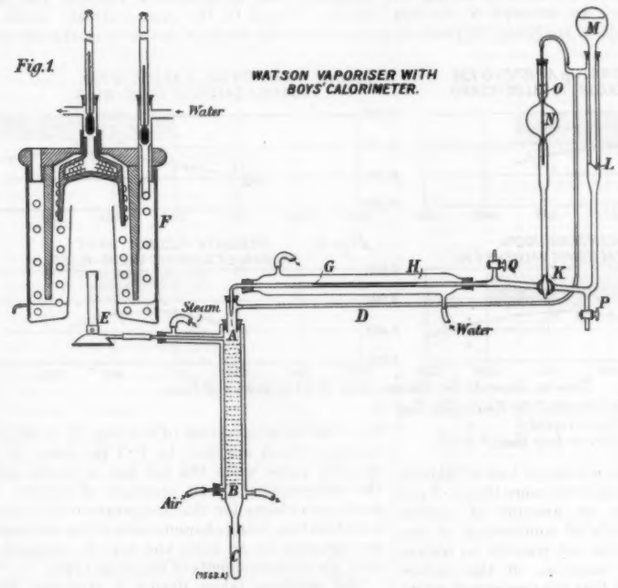
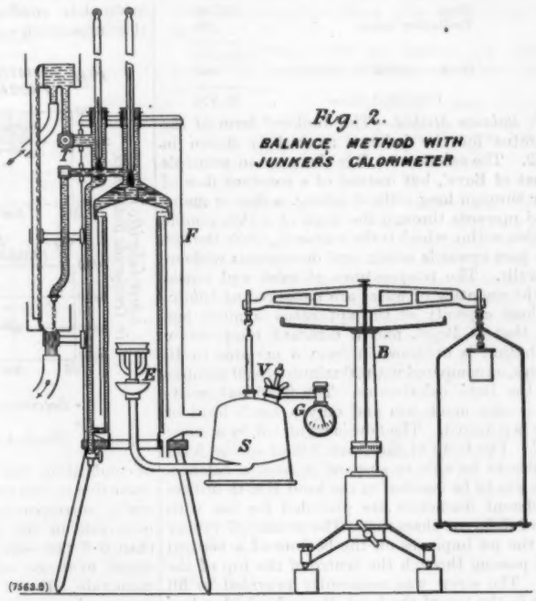


Fig. 2.

BALANCE METHOD WITH JUNKERS' CALORIMETER



with the vapour in the Bunsen burner and chimney.

In earlier experiments the air was supplied from large gas bags kept under pressure by weights, but in later experiments a small blower such as is used for small glass-worker's blowpipes was used. It will be seen that air, steam, and water flows are all required as accessories. The air has to be regulated with great care to obtain perfect combustion and has to be constantly watched. An alteration of fuel flow during a series of determinations can only be made by changing the level of both L and O, returning to flow from M until steady conditions are again obtained and refilling N. As volumes cannot be measured as accurately as weights, N should be at least 50 c.c. and the time of a determination is proportionately long. The apparatus, being of glass, is fragile.

In experienced hands the apparatus can be relied upon to give consistent and accurate results, but it requires an observer of some care and skill. The following gives the details of a series of results for aviation petrol :—

Lower calorific value (uncorrected)—	C.H.U.
March 11	10,720
March 14	10,680
March 17	10,830
Mean	10,750
Radiation losses	20
	10,770
Heat supplied in vaporiser...	300
Corrected value ...	10,470

IV. *Balance Method.*—The Junkers' form of the apparatus for the balance method is shown in Fig. 2. The calorimeter F is the same in principle as that of Boys', but instead of a constant flow of water through long coils of tubing, a flow is maintained upwards through the walls of a thin double cylinder, within which is the burner E, while the hot gases pass upwards within and downwards without the walls. The temperatures at inlet and outlet and the quantity of water are measured as before. The heat capacity of the apparatus is much less than that of Boys', and a constant temperature distribution is obtained in from 5 minutes to 10 minutes, as compared with 20 minutes to 30 minutes with the Boys' calorimeter. The frictional resistance is also much less and only a small head of water is required. The flow is regulated by a screw tap T. The body of the stove S is of special form in order to be able to suspend it from a balance. Three jets to be inserted in the head E with orifices of different diameters are provided for use with fuels of different character. The stream of vapour from the jet impinges on the bottom of a vertical screw passing through the centre of the top of the head. The screw was apparently provided to fill a hole in the top of the head, through which a box spanner could be inserted to change the jets. It was afterwards found useful, however, in regulating the character of the flame obtained. Very minute differences in the level of the screw end on which the stream of vapour impinged were sufficient to alter completely the character of the flame from a blue roaring small one to a large and luminous flame. In all ordinary cases the screw required to be fixed down tight in its lowest position.

A ring round the head is so shaped as to direct the flame upwards instead of horizontally, thus assisting the draught and preventing the flame from playing on the walls of the chimney. An ordinary cycle tyre valve is fixed at V, and through it air can be pumped to the required pressure, as noted on the gauge G. A release valve on the gauge serves to give a reduction in pressure if the rate of fuel consumption is too high. The balance B is of simple and heavy construction.

The burner having been lighted and the water flow regulated to give a temperature rise of about 15 deg. C., time is allowed for the attainment of steady conditions, and the weight counterbalancing that of the burner is made slightly less than that necessary for balance. As the fuel burns away and balance is produced, the pointer crosses the zero mark and the time is noted. Ten grammes are then removed from the balance, and the water flow and temperatures are noted continuously until the pointer again crosses the zero mark. Stops were placed under the arms of the balance in order that the swing should be small, as it was found that a rise or fall of the burner produced a temporary small change in the temperature rise. A large difference in the position of the burner within the calorimeter produces a permanent difference in temperature rise. The first experiments were made with both calorimeter and balance resting on the table, but in the later ones the balance and burner were raised 3 in., the heat losses being thereby reduced from about 1·5 per cent. to 0·5 per cent. of the calorific value. The burner could not be raised further owing to the horizontal portion of the connecting tube, and it was also not considered expedient to try higher positions as slight continuous fluctuations of the hot temperature are produced when the burner is high. No further attempt was therefore made to reduce the heat loss, but its value was found by experiments at various rates of water flow and fuel consumption.

In order to maintain steady burning with fuels of different character, it is necessary to use jets with different orifices, and to obtain the correct calorific value it is also necessary to restrict the rate of fuel consumption within certain limits which depend on the fuel and on the kind of jet. These limits, however, are wide. If too much fuel is burnt, low values are obtained presumably owing to incomplete combustion. An attempt to confirm this supposition was made by analysing the products of combustion, but as the maximum loss of calorific value due to this cause was never more than 1·5 per cent., corresponding to an amount of carbon monoxide in the products of combustion of less than 0·5 per cent., it was not possible to obtain direct evidence of the existence of the carbon monoxide. It was found that the presence of white flame was not necessarily an indication of incomplete burning. Experiments were made with the same rate of fuel consumption (1) with the screw of the burner head in its lowest position and a small blue flame, and (2) with the screw raised by one screw thread and a large white flame. Exactly the same calorific value was obtained, so that it appears that the combustion was completed in the flame outside the white portion. If a low rate of fuel consumption is used, then the heat lost by radiation becomes appreciable and the calorific value is again low. The heat lost by radiation was never more than 1·5 per cent. and a correction for it can be made. With a very low rate of consumption the flame becomes unsteady.

The rate of water flow should also be adjusted so that the temperature rise lies between 12 deg. and 20 deg. C. The hot temperature is in a constant slight fluctuation of about 0·05 deg. C. and the temperature rise would therefore not be obtained with sufficient accuracy if it were less than the lower value, while if the rise is over 20 deg. C. the radiation loss is increased. After a lengthy preliminary series of experiments on petrol with very large and small temperature rises and with medium and slow rates of fuel consumption in order to determine the correction necessary for radiation losses, series of experiments were made with aviation petrol, benzene, absolute alcohol and paraffin oil in order to determine the limits of the consumption rates and the jet required for these fuels. The results are shown without exception in Figs. 3 to 6, and it will be seen that if the rates of burning are kept within the wide limits of the shaded areas, then each individual result is within 0·5 per cent. of the probable value.

In addition to the radiation correction, there is a small correction of opposite sign necessary owing to the diminution in the rate of fuel consumption and temperature rise during the progress of the determinations. Owing to the loss of fuel from the reservoir of the stove the pressure falls a little and hence the rate of fuel outflow. In order to minimise this, not more than 100 grammes of fuel should be placed in the reservoir, but even then the hot temperature falls on an average 0·5 deg. C. during the consumption of 10 grammes of fuel. The hot end of the calorimeter and the water it contains thus hold less heat at the end of the experiment than that which they held at the beginning, and the difference has been given to the water in addition to that supplied by the fuel. The necessary correction was determined by experiments on the rate of cooling after the burner had been quickly extinguished, and also by a comparison of the results obtained under normal conditions with those obtained when the temperature was caused to be higher at the end of the experiment than at the beginning due to gradually choking the water supply. Owing to the comparatively small heat capacity of the Junkers' instrument, the correction for a fall in temperature of 0·5 deg. C. is only 300 calories, which amounts to 0·3 per cent. of the calorific value when the fall has occurred during the consumption of 10 grammes of petrol. The small corrections for this temperature fall and for radiation loss, being characteristic of the instrument, are the same for all fluids and may be assumed the same for all instruments of the same type.

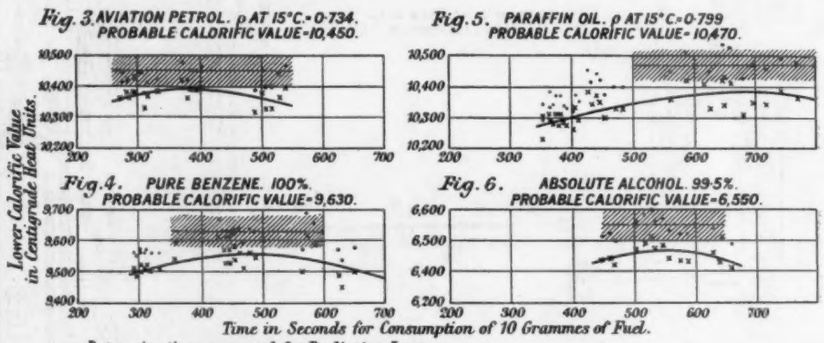


Fig. 3. AVIATION PETROL. ρ AT 15°C.=0·734. PROBABLE CALORIFIC VALUE-10,450.
Fig. 5. PARAFFIN OIL. ρ AT 15°C.=0·799 PROBABLE CALORIFIC VALUE-10,470.
Fig. 4. PURE BENZENE. 100%. PROBABLE CALORIFIC VALUE-9,630.
Fig. 6. ABSOLUTE ALCOHOL 99·5%. PROBABLE CALORIFIC VALUE-6,550.
Lower Calorific Value in Centigrade Heat Units.
Time in Seconds for Consumption of 10 Grammes of Fuel.
* Determinations corrected for Radiation Loss
× " uncorrected " " "
Shaded Area; Error less than ± 0·5%
(7563c)

The readings taken during a specimen determination are given below :—

Aviation Petrol.

Density at 15 deg. C. = 0·734 grammes per c.c.
Weight burnt ... ... 10 grammes.
Time ... ... 404 seconds = T.
Air temperature ... 15 deg. C.
Temperature of products of combustion leaving the calorimeter ... 17 deg. C.

Temperatures. Deg. C.	Deg. C.	Rise. Deg. C.	Water Flow.
9·73	25·77	16·04	
9·73	25·78	16·05	
9·72	25·70	15·98	
9·70	25·60	15·90	2,095 c.c. in 120 secs.
9·70	25·60	15·90	
9·70	25·53	15·83	
9·70	25·50	15·80	
9·72	25·40	15·68	
9·71	25·44	15·73	2,040 c.c. in 117 secs.

Mean rise ... ... 15·88 deg. C. = t.
Mean water flow ... 17·44 c.c. per sec.
Hot temperature fall ... 0·33 deg. = t_1.
Condensed water ... 12·5 grammes at 17 deg. C.

Heat received by water	= 15·88 × 17·44 × 404	Calories. = 111,890
Heat lost by radiation	= T t/10	= 640
		112,530
Heat gained from calorimeter, 600 t_1		= 200
		112,330
∴ Higher calorific value per gramme		= 11,230
Heat received from condensed water	= 1·25 × 620	= 770
∴ Lower calorific value per gramme		= 10,460

For the four fuels used the results obtained may be summarised as follows. Details of the individual values are shown in Figs. 3 to 6 :—

(a) *Aviation Petrol.*

Density at 15 deg. C. = 0·734 grammes per c.c.

Approximate diameter of orifice for steady burning, 0·04 cm.

Limits of rates of combustion for best results, 250 seconds to 550 seconds for 10 grammes.

Calorific value obtained, 10,450 calories per gramme.

Experimental values given by Ricardo (*The Automobile Engineer*, February, 1921), 10,490 for petrol of density 0·723 and 10,430 for petrol of density 0·760.

(b) *Pure Benzene, 100 per Cent.*

Density at 15 deg. C. = 0·884 grammes per c.c.

Approximate diameters of orifices for steady burning, 0·04 cm. and 0·025 c.m.

Limits of rates of combustion for best results (lower than for petrol), 350 seconds to 600 seconds for 10 grammes.

Calorific value obtained, 9,630 calories per gramme.

Experimental value given by Ricardo, 9,620 calories per gramme.

Calculated value given by Tizard and Pye (*The Automobile Engineer*, February, 1921), 9,640 calories per gramme.

(c) *Paraffin Oil.*

Density at 15 deg. C. = 0·799 grammes per c.c.

Approximate diameter of orifice for steady burning, 0·025 cm.

Limits of rates of combustion for best results are lower than for petrol or benzene, but the velocity of the vapour must be high and hence the small orifice used, 500 seconds to 800 seconds for 10 grammes.

Calorific value obtained, 10,470 calories per gramme.

Experimental value given by Ricardo, 10,550 for paraffin oil of density 0·813.

(d) *Absolute Alcohol, 99·5 per Cent.*

Density at 15 deg. C. = 0·7934 grammes per c.c.

The velocity of the vapour emerging from the jet should be low and hence a jet of large orifice is supplied, but even with the lowest pressures the rate of outflow was so large that the Primus burner was unable to vaporise it all, and liquid alcohol was spasmodically ejected, giving a series of miniature explosions and incomplete combustion. With smaller orifices the velocity of the vapour was greater than that of the flame propagation, and accordingly the flame could not be maintained. It was found, however, that by slightly raising the central screw previously mentioned on which the jet impinged, the velocity could be reduced and the flame maintained. If the screw was raised too high, the flame was ejected downwards and was very unsteady.

Diameter of orifice, 0·04 cm.

Limits of rates of combustion for best results, 450 seconds to 650 seconds for 10 grammes.

Calorific value obtained, 6,550 calories per gramme.

Experimental value given by Ricardo, 6,370 calories per gramme for 98 per cent. alcohol.

Calculated value given by Tizard and Pye, 6,450 calories per gramme.

A detailed examination of the factors concerned in the determination of a result shows that an accuracy of one part in 250 should be expected provided that complete combustion is obtained. The accuracy with which each factor was measured is given in the statement below :—

Water flow, 5 c.c. in 2,000 c.c.

Time of water flow, 0·2 second in 80 seconds for the greatest flow used.

Temperature rise, measured to 0·01 deg. in 12 deg. C. for smallest rise, but the probable accuracy of mean value was estimated at 0·02 deg. C. owing to small fluctuations.

Time of fuel consumption, 0·5 second in 250 seconds for smallest time recommended.

Weight of fuel consumed, 0·025 gramme (half division of balance scale) in 10 grammes.

Each factor can thus be measured to 1 part in 400 and the final results, as shown in Fig. 3, are all within 1 part in 200 of the probable value. Furthermore, the corrections due for radiation loss and for temperature fall, and the error due to incomplete combustion (except when liquid was ejected in the case of alcohol), are all so small that uncorrected results obtained without any precautions as to the limits for rates of combustion were only less than the probable value by amounts varying from 0·5 per cent. to 1·5 per cent., the temperature rise being less than 20 deg. C. If an approximate value is only desired, it is only necessary to add 1 per cent. to any uncorrected value and the result will be correct to 1 per cent. If the limits are observed and the proper corrections are made as shown in the specimen result, the answer should be correct to 0·5 per cent.

FULLY HYDRO-ELECTRIC POWER STATION, SWITZERLAND.

(Concluded from page 670.)

IN the description of the pipe line in our previous article, the question of loss of head and of net head has not been referred to. The net head has been arrived at as follows. The maximum delivery of the pipe line has been considered to reach 800 litres (178 gallons) per second. The total head is :

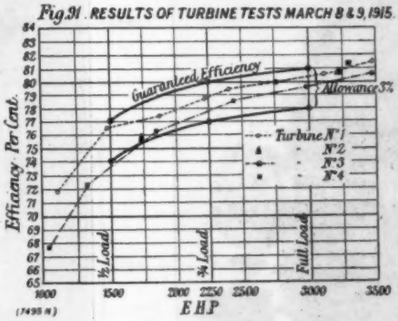
	M.
Maximum level at the lake ...	2,145·00
Centre of axis of turbines	501·10
Maximum total head	1,643·9
Utilisable fall in the lake level (Figs. 5 and 14 *ante*) down to 2,121 m., or a water depth at the lake of ...	24·0
Hence the minimum total head=	1,619·9

The loss of head at the maximum flow of 800 litres per second has been calculated as follows :—

Upper section of pipe line; diameter, 600 mm.; length, 2,278 m. (Fig. 5 *ante*); 18·8 mm. (18·8 per 1,000) per metre ...	43·0
Lower section; diameter, 500 mm.; length, 2,347·5 m. (Fig. 5 *ante*); 48·2 mm. (48·8 per 1,000) per metre	113·0
Inlet, inlet valves and bends ...	2·95
Automatic valve at tunnel outlet	2·70
500-mm. sluice valve	0·35
Delivery to the power station, three bends, hydraulic valve and sluice valve	2·10
Branches to the turbines and 250-mm. valves	1·60
	165·70

which is about 10 per cent of the total head.

Fig. 91. RESULTS OF TURBINE TESTS MARCH 8 & 9, 1915.



The velocity of the vapour emerging from the jet should be low and hence a jet of large orifice is supplied, but even with the lowest pressures the rate of outflow was so large that the Primus burner was unable to vaporise it all, and liquid alcohol was spasmodically ejected, giving a series of miniature explosions and incomplete combustion. With smaller orifices the velocity of the vapour was greater than that of the flame propagation, and accordingly the flame could not be maintained. It was found, however, that by slightly raising the central screw previously mentioned on which the jet impinged, the velocity could be reduced and the flame maintained. If the screw was raised too high, the flame was ejected downwards and was very unsteady.

Diameter of orifice, 0·04 cm.

Limits of rates of combustion for best results, 450 seconds to 650 seconds for 10 grammes.

Calorific value obtained, 6,550 calories per gramme.

Experimental value given by Ricardo, 6,370 calories per gramme for 98 per cent. alcohol.

Calculated value given by Tizard and Pye, 6,450 calories per gramme.

A detailed examination of the factors concerned in the determination of a result shows that an accuracy of one part in 250 should be expected provided that complete combustion is obtained. The accuracy with which each factor was measured is given in the statement below :—

Water flow, 5 c.c. in 2,000 c.c.

Time of water flow, 0·2 second in 80 seconds for the greatest flow used.

Temperature rise, measured to 0·01 deg. in 12 deg. C. for smallest rise, but the probable accuracy of mean value was estimated at 0·02 deg. C. owing to small fluctuations.

Time of fuel consumption, 0·5 second in 250 seconds for smallest time recommended.

Weight of fuel consumed, 0·025 gramme (half division of balance scale) in 10 grammes.

Each factor can thus be measured to 1 part in 400 and the final results, as shown in Fig. 3, are all within 1 part in 200 of the probable value. Furthermore, the corrections due for radiation loss and for temperature fall, and the error due to incomplete combustion (except when liquid was ejected in the case of alcohol), are all so small that uncorrected results obtained without any precautions as to the limits for rates of combustion were only less than the probable value by amounts varying from 0·5 per cent. to 1·5 per cent., the temperature rise being less than 20 deg. C. If an approximate value is only desired, it is only necessary to add 1 per cent. to any uncorrected value and the result will be correct to 1 per cent. If the limits are observed and the proper corrections are made as shown in the specimen result, the answer should be correct to 0·5 per cent.

For the calculation in regard to the 600 mm. and 500 mm. portions of the pipe line, means have been taken between the figures given in the Van Muyden diagram (for pipes in service for a lengthy period) and the Weissbach coefficients (for new pipes). In reality, the loss of head is less than that given by calculation, which is not surprising considering that the whole line consists of pipes perfectly smooth inside. The proportion of 10 per cent. may appear somewhat high. It should be remembered, however, that the Fully installation is essentially a reserve one, destined to supply its maximum power during a relatively short period of the year. The maximum net head at the flow of 800 litres per second, i.e., when the four turbine sets are working at full power, is therefore 1,643·90 — 165·70, or 1,478·20 m. (4,850 ft.). At the lowest lake level, 2,121 m., the minimum net head is 1,454·20 m. (4,772 ft.), also at the flow of 800 litres per second.

The turbines have been designed for a flow of 200 litres (44 gallons) per second at this minimum net head, and for a normal power of 3,000 h.p. each, this power to be developed even when the head falls to 1,500 m. (4,921 ft.). Should the head decrease still further, the power would drop below 3,000 h.p. On the other hand, the 3,000 h.p. can be exceeded, even to a considerable extent when less than four sets are running, as is seen by the test results given in Fig. 91. When only three sets are running, the net head is about 1,550 m. (5,085 ft.); when two, it is about 1,600 m. (5,250 ft.). The tests were carried out with a net head of 1,620 m. (5,315 ft.).

With reference to the characteristic features of the turbines, great stress was laid upon the means for preventing these racing, so as to eliminate all risk of bursting. It will be noticed that the mean diameter of the wheel at the bucket centres is 3·550 m. (11 ft. 8 in.), which at the normal turbine speed of 500 revolutions, corresponds to a peripheral speed of U = 93 m. (305 ft.) per second. For the maximum head of 1,643·90 m. the theoretical value of the water velocity $\sqrt{2gh}$ is 180 m. (590 ft. 6 in.) per second, and for the minimum net head of 1,454·20 m. it is 168·50 m. (552 ft. 10 in.) per second. The ratio $\frac{U}{\sqrt{2gh}}$ is 0·517 in the first instance and 0·550 in the second, values which are perceptibly higher than those generally reckoned upon for Pelton turbines. This has been done intentionally with a view to limiting racing speeds.

The following are the figures for efficiency guaranteed by the manufacturers for three different racing speeds :

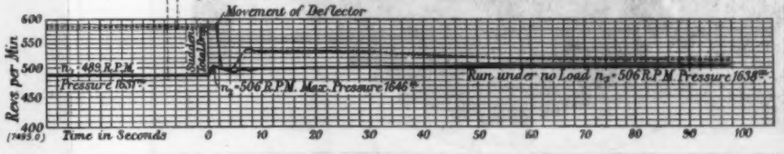
	Revs.	Revs.	Revs.
Racing limited to ...	850	750	700
Guaranteed efficiency :	Per cent.	Per cent.	Per cent.
Full load	82	81	79
Three-quarter load	81	80	78
Half-load	78	77	75

The limiting racing speed allowed was 750 revs., and as will be seen 1 per cent. efficiency only is sacrificed by this, while the coefficient of safety is largely increased, since the stresses due to centrifugal force increase as the square of the speed. At the racing speed test, the speed of 750 revs. was not exceeded and not even reached; 732 revs. were attained, with the alternator coupled to the turbine, and 737 revs. when the turbine ran alone. This affords another indication of the precautions taken in this installation.

The turbines are illustrated in Figs. 76 to 78, Plate XLIV, with this week's issue, various details being given on the same Plate. A discharge pipe and the tail race channel are shown in Fig. 83. Details of the governor are given in Figs. 82, and 84 to 90,

Fig. 92. SPEED DIAGRAM FOR SUDDEN DROP OF 2200 KW. IN LOAD.

Max. Difference in Speed Δ_n = 506-489·17 Revs or 3·37%
Overpressure Max. = 1646-1631·15 m
Trials of March 9th 1915 Turbine N°3


Angular Displacement of Needles
Movement of Deflector
Revs per Min.
Time in Seconds
Run under no Load n_0 = 506 R.P.M. Pressure 1638 m
n_0 = 489 R.P.M.
Pressure 1631 m
n_0 = 506 R.P.M. Max. Pressure 1646 m

While its operation is indicated in the diagrams, Figs. 95 to 97, on page 733. Fig. 91 is a diagram giving the tests carried out on the four turbines, whilst Fig. 92 is a speed diagram for a sudden drop of 2,200 kw. in the load. We may here remark that the turbine manufacturers have since made jets and darts with which they guarantee an increased efficiency of 2 per cent. to 3 per cent.

If the high figure of the ratio of the turbine wheel diameter to the diameter of the jet be considered, namely $\frac{3,500}{38}$, or 93·5, and the very low number of specific revolutions, namely

$$n_s = \frac{n}{h}\sqrt{\frac{N}{\sqrt{h}}} = \frac{500}{1,600}\sqrt{\frac{3,000}{1,600}} = 2·7,$$

it will be found that the results obtained are highly satisfactory. They have been secured by the very careful manufacture of the buckets, nozzles and darts. The buckets are of forged steel, and the internal surfaces on which the water impinges were carefully polished. The nozzles and darts or needle valves are of tempered steel. The

turbines have stood perfectly up to their work since 1915, when they started running; there is no appreciable wear on the buckets. The needles and nozzles have been trimmed up or replaced a few times. As soon as the efficiency of a turbine is found to decrease, the nozzle and needle are replaced. The output is easily gauged from the flow at the weir at the end of the tail race, where a Woltmann water meter and a float indicator have been fitted.

The turbine wheel, which is illustrated in Fig. 93, subjoined, acts as a flywheel and is a forged Siemens-Martin steel disc, weighing 7,100 kg. (about 7 tons) when machined. At racing speed CC the transverse wedges. The parts can also be seen plainly in Fig. 79, on Plate XLIV.

This method of fixing, although seemingly a most natural one, does not, owing to the very great influence of friction effects of the wedges, allow of estimating in advance with a sufficient degree of certainty what will be the maximum stresses in the various elements. It is, of course, essential to produce between the contact surfaces of the buckets, wedges and disc, stresses sufficient to prevent all risk of these elements working loose, whatever the rate at which the turbine runs, and without risk of producing in the buckets or the ring stresses exceeding those which are permissible for the material

effect) for the revolving parts of one turbine and its alternator :—

	Kgm.²
For a turbine, about	48,000
For an alternator, about	19,000
Or a total PD² of about	67,000

Governing is double, and the action on the dart of the jet is a slow one (40 seconds), whilst the action on the jet deflector is very rapid (2 seconds). The guarantees as to speed variation, etc., demanded in the contract were the following: If full load is instantaneously thrown off the whole of the plant, the excess pressure in the pipe line is to be less than 5 per cent. If 50 per cent. of the load is

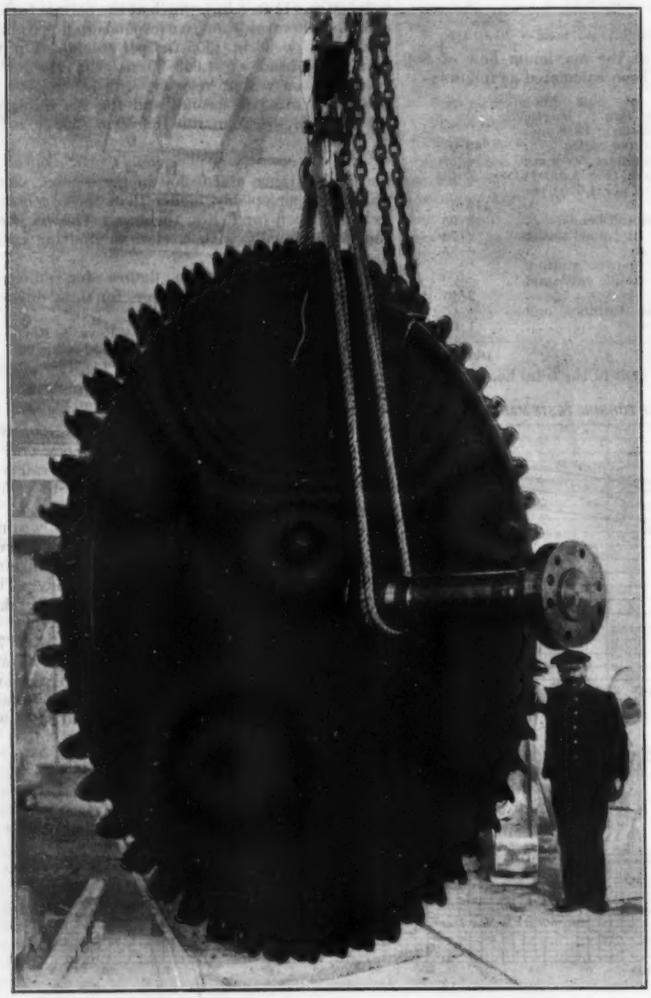


Fig. 93. Disc of Pelton Wheel.

Fig. 94. Method of Fixing Buckets.

the stresses in the steel do not exceed 10 kg. per square millimetre (6·35 tons per sq. in), this giving a factor of safety of from 4 to 5. The method of fixing the buckets to the wheel is illustrated in Fig. 94, annexed. The wheel is fitted with 54 buckets, each having an average weight of 11·4 kg. (25 lb.), and on each impinges a water jet 34 mm. (1·338 in.) in diameter (38 mm. (1·496 in.) maximum). The turbine disc is fitted on a steel shaft on a tapered seat, the shaft being carried in bearings 600 mm. (23·6 in.) in length, 200 mm. and 240 mm. (7·9 in. and 9·4 in.) in diameter, provided with ring lubrication. The buckets are carried by the wheel in a dovetail groove, into which they are dropped through morticed slots. They are fixed in position at the proper intervals round the rim, by means of wedges driven between them in a direction across the rim. The arrangement will be clear from Fig. 94, in which AA are the buckets, R is the dovetail groove, EE the mortice slots, and

itself. Of the 54 axial wedges, nine of special shape were first driven into the disc; they form starting points for the ring of buckets. The others, of trapezoidal and constant section, were carefully fitted so as to produce a moderate initial tightening. The disc, without the buckets, was then very slowly heated in a specially-built electric furnace to a temperature of about 130 deg. C., this producing a considerable expansion of the peripheral length of the ring. The cold buckets were then inserted together with the axial wedges, and it was possible to introduce between the rim of the disc and nine of the trapezoidal wedges chosen symmetrically round the disc a steel sheet shim of the required predetermined thickness to produce on shrinkage the necessary tightening-up. The buckets cannot get free of the disc, even if the tightening wedges were to fail, and the latter eventuality was rendered impossible by heading the wedges over.

The following are the values of P D² (flywheel

instantaneously thrown off, speed variations are not to exceed 3 per cent., or 7 per cent. when 100 per cent. is instantaneously thrown off. In addition, hand regulation is possible while running up to 6 per cent. This speed variation can be effected by hand at the governor itself, or from the station switchboard by means of small electric motors; this greatly facilitates the running in parallel of the sets themselves and of these in conjunction with the units at the Martigny power station, for which the Fully station acts as a reserve. The working of the governors was satisfactory from the commencement. In the case of sudden and large variations in the load, the passing from the first speed to the second is carried out very regularly, as can be seen from the diagram, Fig. 92.

The working of the governor is illustrated diagrammatically in Figs. 95 to 97. Fig. 95 shows the conditions under full load, the deflector being clear of the jet, and the rocking lever bearing

against the stop 9. Fig. 96 shows the first governing movement in which the deflector is interposed in the line of the jet, the latter being entirely deflected by it, while the dart is still in its original position, the point 8 having not yet shifted, by reason of the action of the link system 6–8–12–10 and of the fact that the cylinder 4 of the dash pot drawn by the piston 3 has had the same travel as the pistons 2 and 1, to which it is connected. The rocking lever 7 has therefore travelled away from the stop 9. In Fig. 97 the cylinder 4 of the dash pot, after having slowly travelled from left to right, has raised the deflector 12, and, by means of the connecting bar 11, has also shifted the dart, thus adjusting the size of the jet. The apparatus itself is illustrated in Figs. 82, and 84 to 90, details of the governor appearing in Figs. 84 to 90. The link system and dashpot, etc., are clearly shown in the section in Fig. 88. In that figure the crank lever to the left is that connected with the deflector, while the one connected with the dart is shown to the right-hand end of the gear. The dart mechanism is shown in detail in Fig. 82. It will be seen that the distribution valve is placed directly underneath the centrifugal governor, which obviates the interposition of gearing. In the device for controlling the closing speed of the dart, the oil circulates in a helical groove, the length of which can be increased at will, a method which is specially applicable in installations similar to the one at Fully, where it is important to secure a very slow closing, in 40 seconds to 50 seconds. The oil pump which supplies the governor is on the turbine shaft on the opposite side to that of the alternator, as shown in Figs. 76 to 80. This pump having eight radial pistons. It is shown in section in Fig. 81. The centrifugal governor is operated by a horizontal shaft and two sets of worm gearing, the whole enclosed in a casing. There being no belt, all risk under this head is obviated.

Fig. 95.

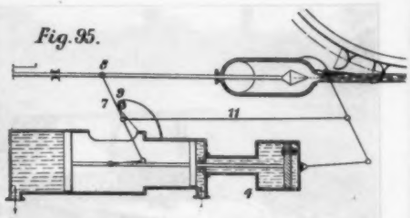


Fig. 96.

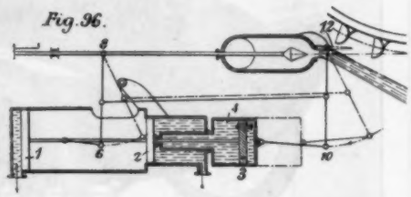
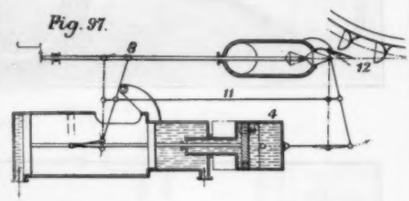


Fig. 97.



fixed armature and rotating fields, carried in two bearings, the exciter being at the end of the shaft. They are rigidly connected by a shaft coupling to the turbines. Their characteristic features are the following :—

Effective power	2,800 k.v.a.
Power absorbed, cos ϕ = 0·75 ...	3,000 h.p.
Voltage between phases ...	10,000 volts.
Speed	500 r.p.m.
Frequency	50 periods.
Flywheel effect P D^2 ...	19,000 kgm.^{2}
Exciting power required, under full load, cos ϕ = 0·8 ...	About 18 kw.

Guaranteed efficiency	Cos ϕ = 1. per cent.	Cos ϕ = 0·8. per cent.
Under full load ...	95·5	94·5
Under half load ...	93·0	91·5
Voltage drop ...	12·0	25·0

The windings were tested to the following pressures :

Armature	20,000 volts.
Field	500 volts.

The rotor can withstand without danger a racing speed 1·8 times the normal.

The alternators are connected to the bus-bars by triplex, lead-sheathed, armoured cables, 3 × 100 mm.^{2}, running under the floor of the engine-room. The exciting current leads also consist of lead-sheathed, armoured cables, 2 mm.^{2} by 150 mm.^{2}, for the alternator, and of 2 mm.^{2} by 8 mm.^{2} for the exciter. These cables are insulated, the former for 10,000 volts (tested up to 20,000 volts) and the latter for 1,000 volts (tested up to 2,000 volts).

The electric installation (switches, electrical safety devices, etc.), is of the usual type. The pumping station referred to in the foregoing contains three single-phase oil-cooled transformers, forming a three-phase set of 600 k.v.a. at 10,000/750 volts and 50 periods. These transformers supply a three-phase, slip-ring 600-h.p. motor, direct coupled to the centrifugal pump.

In designing the power station, care was taken to construct a building which had not the appearance of a factory, and did not clash to too great an extent with the surrounding scenery. That this intention has been achieved is shown by the view, Fig. 74, page 669 *ante*, from which it will be seen that the lower floor is arranged with natural light, which is a considerable advantage. The pipe line being underground over its whole length does not mar the landscape. The engine-room is served by an 18-ton hand-operated overhead traveller. The water on leaving the turbines is collected in steel pipes, whence it flows into a concrete conduit 0·80 m. (31·5 in.) inside diameter. The use of steel pipes was necessary owing to the deflection of the jet, this having a velocity in the neighbourhood of 165 m. (540 ft.) per second. The concrete conduit ends in a gauging channel, at the entrance of which are provided perforated plate screens for eliminating eddies in the water flow and enabling constant gauge readings to be taken. These readings allow the working of the turbines to be regulated at any time. One end of the building is set apart as a repair and maintenance shop.

Fig. 98.

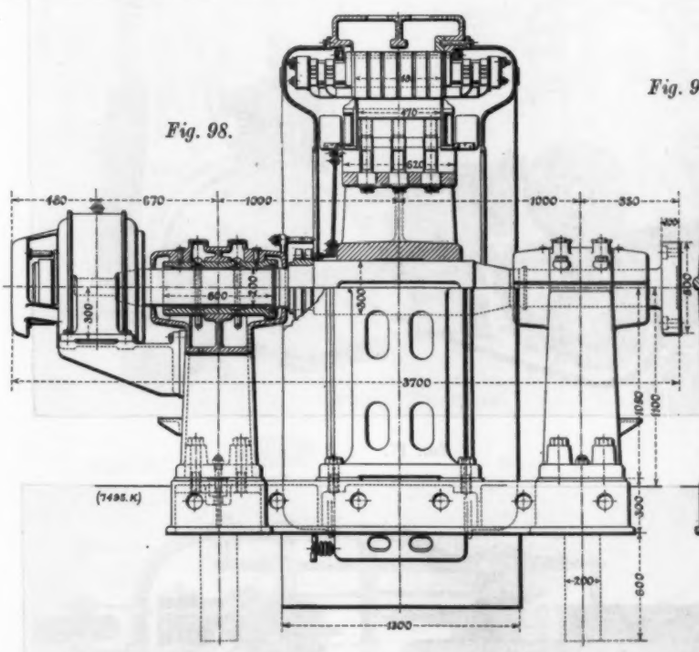
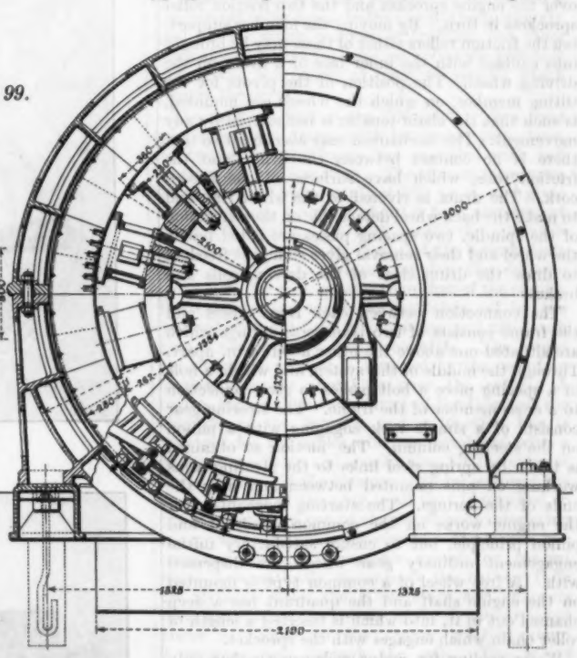


Fig. 99.



The electric part of the power station has no special features. The alternators are illustrated in Figs. 98 and 99. Each alternator can be connected indifferently to three sets of bus-bars from which originate three lines. Two of these join up by means of a coupling station to the Martigny power station system. The third connects up at Vouvry to the system of the Société Romande d'Electricité, Territet. A fourth line distributes current for the working of the rope railway, and for the Sorniot pumping station ; this latter can be connected to either of two of the bus-bar systems. Power transmission is at 10,000 volts for the lines connected to Martigny, and at 25,000 volts for those at Vouvry. The alternators are of the usual type, with

The head utilised at the Fully Station is considerably higher than any other in the world and, as will be gathered from the foregoing, the unique features of the installation give to it an exceptional interest. We are indebted to Messrs. H. Chenaud and L. Du Bois, engineers, of Lausanne, Vaud, Switzerland, for the complete particulars we have been able to give in these articles.

All civil engineering work connected with the plant was carried out by Messrs. Martin and Baratelli, contractors, Lausanne ; the turbines were built by the Société Anonyme des Ateliers Piccard, Pictet

and Co., Geneva; the alternators and electrical fittings by the Ateliers de Construction Oerlikon; and the pipe line by Messrs. Thyssen and Co., Mülheim. The laying of the pipe line and of the rope railway was carried out under the supervision of Mr. A. Boucher. The valves, special pipes, collectors, etc., were manufactured by the L. de Roll Works, Clus; the superstructure of the power station and the overhead travelling crane were supplied by the Ateliers de Constructions Mécaniques, Vevey; the railway winches by the L. de Roll Works, Bern, and the rolling-stock by Messrs. Oehler and Co., Aarau. The pumping station was put down by Messrs. Brown, Boveri and Co., Baden.

THE CYCLE AND MOTOR-CYCLE SHOW.

(*Concluded from page* 707.)

One of the most original exhibits at the Show on this side was the three-wheeler manufactured by Xtra Cars, Limited, of Chertsey, Surrey, which is illustrated in Figs. 16, 17 and 18, annexed.

To reduce the cost of construction and the number of parts in the transmission system, the engine unit has been removed from the orthodox position in a motor car to a place much closer to the driving wheel, and on the lighter models, such as that we illustrate, is located in a tubular fork structure. This fork also carries the spindle on which the back wheel turns. Tubular framework for the power unit and transmission gear ensures rigidity. Cross-lugs on the fork are used to obtain support from the wooden frame. The transmission system is probably the most simple in any type of motor vehicle and is cheap to produce. Pivoted on a pin carried on one side of the fork there is a vertical member which carries at its two ends short shafts on each of which is mounted, on ball bearings, a sproket and a friction roller. A single chain passes over the engine sprocket and the two friction roller sprockets in turn. By moving the member supporting the friction rollers either of them may be brought into contact with the inner face of a drum on the driving wheel. The position of the pivots for the tilting member, on which the wheels are mounted, is such that the chain tension is not altered by any movement. The mechanism may also be set so that there is no contact between the drum and the friction rolls, which have surfaces of compressed cork. The drum is riveted to the wheel rim, and to make the back wheel detachable on the extraction of the spindle, two spacing pieces are fitted beside the wheel and their removal gives sufficient freedom to draw the drum clear of the driving rolls and brakes.

The connection between each front wheel and the frame consists of two transverse springs which are situated one above the other about 4 in. apart. Through the middle of this system and within a hole in a spacing piece a bolt passes to give connection to a cross-member of the frame. The steering gear consists of a simple rack engaging with a pinion on the steering column. The motion so obtained is taken by spring steel links to the steering arms working on pins mounted between and near the ends of the springs. The starting mechanism for the engine works on the common quadrant and pinion principle, but to ensure satisfactory initial engagement ordinary gear wheels are dispensed with. A free wheel of a common type is mounted on the engine shaft and the quadrant has a deep channel cut in it, into which is inserted a length of roller chain which engages with the sprocket.

Water cooling for motor-cycle engines has only been used to a limited extent, but that it can be successfully applied is evident from the fact that it has been the standard practice for many years of one firm of repute. The Scott Motor-Cycle Company, of Saltaire, Yorkshire, specialise in the manufacture of motor cycles using water-cooled twin-cylinder two-stroke engines. These machines have obtained many awards in open competitions for speed and reliability, and their record is such that they must be considered as the equal of the best of the four-stroke engined cycles. The construction of both the cycle frame and the engine is illustrated in Figs. 19, 20, 21 and 22, on page 735.

The frame is built up from straight steel tubes brased to lugs and is almost entirely made up of triangles; the connecting link in the lower part of the structure, Fig. 17, is the engine crank-case and gear-box.

The engine illustrated in Figs. 21 and 22 is the $3\frac{3}{4}$ h.p. model, and has a cylinder bore of $2\frac{7}{8}$ in. and $2\frac{1}{4}$ in. stroke. The total cylinder capacity is 532 cub. cm. Crank-case compression is used to raise the pressure of the petrol-air mixture, after

THREE-WHEELED CYCLE CAR.

CONSTRUCTED BY MESSRS. XTRA CARS, LIMITED, CHERTSEY, SURREY.

Fig. 16.

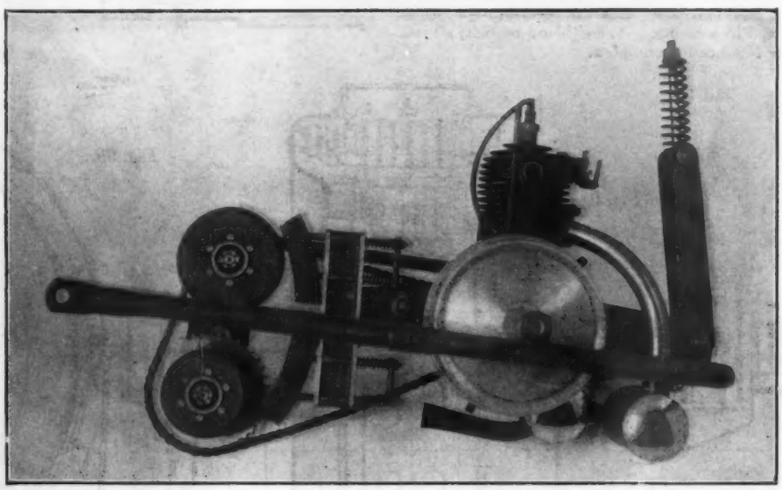


Fig. 17.

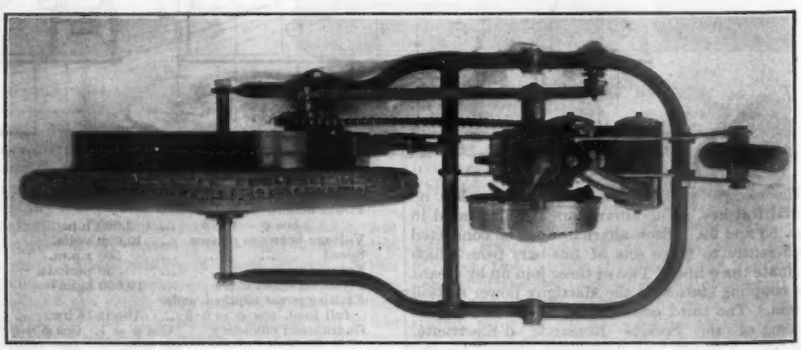


Fig. 18.

EXHIBITS AT THE CYCLE AND MOTOR-CYCLE SHOW.

Fig. 19.

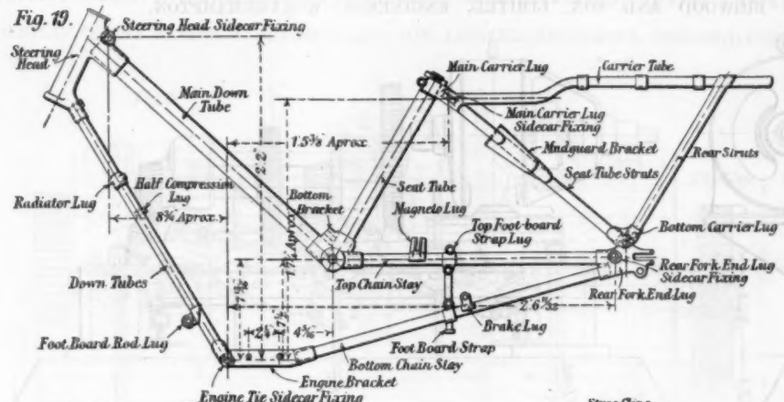


Fig. 20.

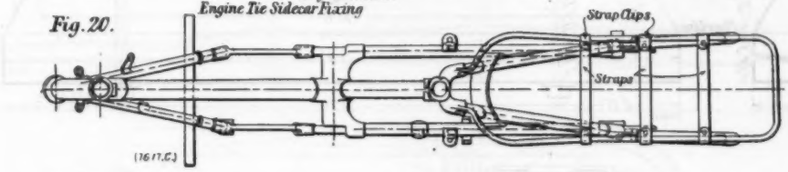


Fig. 21.

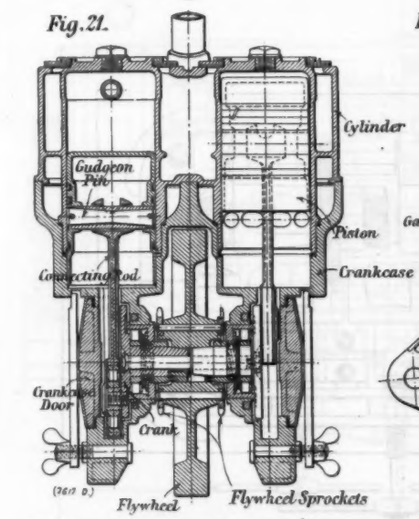
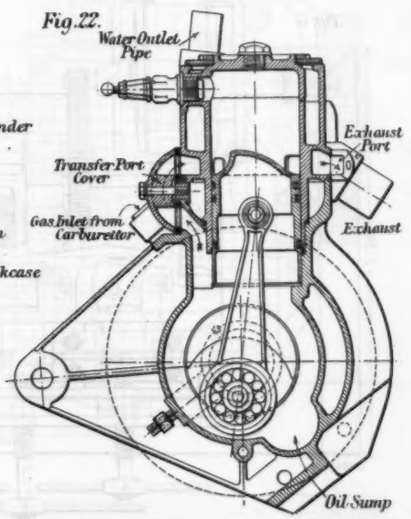


Fig. 22.



FIGS. 19, 20, 21 AND 22. SCOTT MOTOR-CYCLE.—MESSRS. SCOTT MOTOR CYCLE COMPANY, SALTAIRE, YORKSHIRE.

Fig. 23.

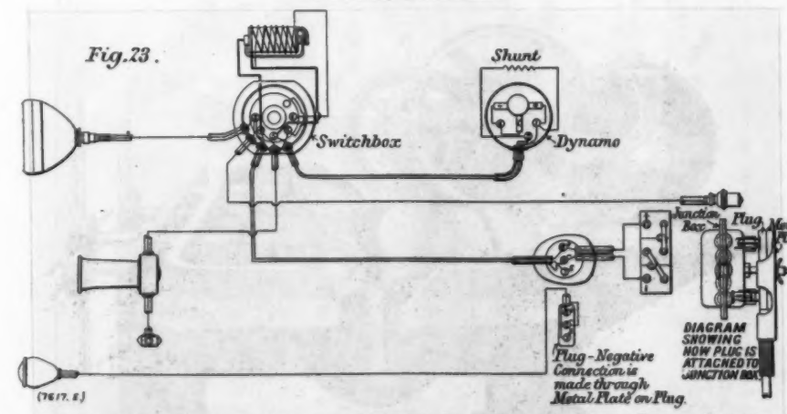


FIG. 23. CONNECTIONS OF MAGDYNO LIGHTING SET.—MESSRS. JOSEPH LUCAS, LIMITED, BIRMINGHAM.

which it is passed into the cylinders by transfer ports (Fig. 22). The crank-cases for the two cylinders are kept reasonably airtight and separate from each other. In the foot of each case there is a sump for lubricating oil. Roller bearings are used for the crankshaft and also in the big ends of the connecting rods. The flywheel is fitted into the recess between the two crank-cases, and fixed beside it are the two main driving sprockets. The form of the piston, the position of inlet and exhaust ports and the construction of the water jackets can be seen in Figs. 21 and 22. The lubrication oil is fed through the roller bearings. When there is a suction in the crank-case, the oil in the oilways is drawn through to the sump in a path which ensures its distribution on the moving parts. A sight feed is provided for the oil going to the bearings, the feed system consisting of a spring-held plunger in a small pump with a needle regulating valve. The radiator, which is provided with tubes formed into a honeycomb construction, is divided by the front down-tube of the frame, and has small drum reservoirs above each section. One of the drawbacks of the two-stroke petrol engine, carbonisation, is much reduced in this engine by the even temperature which is maintained, due to the use of water cooling, and the frequent dismantling of the engine to remove carbon deposits is made quite unnecessary. The piston rings may be examined without removing the cylinders, by taking off the transfer port covers, and the exhaust ports can be got at for examination or cleaning by removing the exhaust covers. Half-compression is obtained by the use of a small exhaust port above the main one, the connection from which to the main exhaust pipe is got by the opening of a small valve. These valves can be removed without dismantling the cylinders by unscrewing lock rings which hold them in position. In this model of the Scott motor-cycle a three-speed gear of the sliding dog type is fitted.

Recognising the difficulties introduced by having an electrical generator whose armature serves both the ignition and the lighting system, Messrs. Joseph Lucas, Limited, of Birmingham, have kept the dynamo quite separate from the magneto armature, but they are housed in the same frame, and the drive for the former is obtained from the magneto by means of gears. Such a construction demands a somewhat taller magneto than would be commonly used for the single purpose of ignition, but other dimensions are kept the same, as well as the bolt-hole centres and the height of magneto spindle which receives the drive.

The magneto part of the "Magdyno" is a good type of modern design with laminated pole shoes, substantial magnet frame and provided with ball bearings for the armature. The dynamo generates a pressure of 6 volts at about 950 r.p.m. and gives its full output, which is about 4 to 5 amperes, at about 2,500 r.p.m. At high speeds the output is maintained constant by means of the intermediate brush method. In normal running the dynamo speed is 80 per cent. greater than that of the engine. The commutator cover can be taken off by the removal of a nut-held lifting strap, and the brush gear is consequently easily accessible. The return circuit for the current is obtained by the use of an insulated copper sheathing over the cables. A switch box enables the control of lighting and the charging of the battery, and a junction box is provided for the cables which is combined with a readily detachable and sturdy plug for the side-car lamp circuit. If the side-car is to be removed the mere removal of the plug is all that is required to cut the side lamp out of circuit without interfering in any way with the cycle circuit. The switch-box contains the electromagnetic switch or cut-out which automatically disconnects the battery from the dynamo when the latter stops and connects them again when the voltage of the dynamo reaches about 7. When on the charge position about 2 amperes pass through the cells. The wiring diagram (Fig. 23, annexed) shows all the connections in the case where the battery is carried on the cycle.

When the switch is in the "charge" position it provides a connection between the connectors marked 6 and E. The supply then follows the path from the generator positive pole to terminal 1 and then to the switch-box stud 5 through the thin coil on the cut-out, and back to stud E, from which it passes through the switch and back to the shunt coil of the dynamo. Electrical connection between the switch-box stud E and the negative brush of the dynamo is maintained through the sheathing of the cables. When the electrical pressure is sufficiently high the pull exerted by the solenoid

THE ABRAMSEN STRAIGHTENING MACHINE FOR BARS AND TUBES.

CONSTRUCTED BY MESSRS. J. BIGWOOD AND SON, LIMITED, ENGINEERS, WOLVERHAMPTON.

Fig. 1

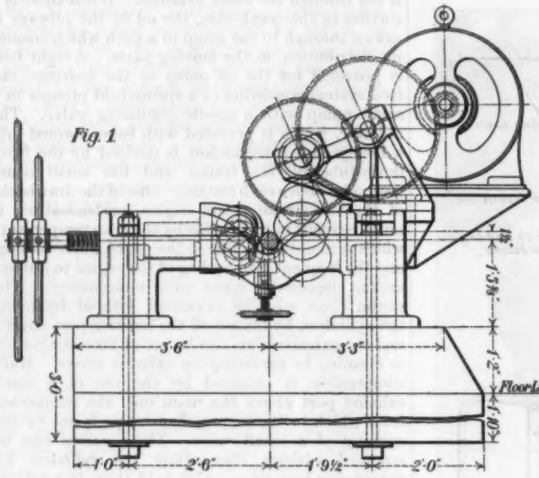
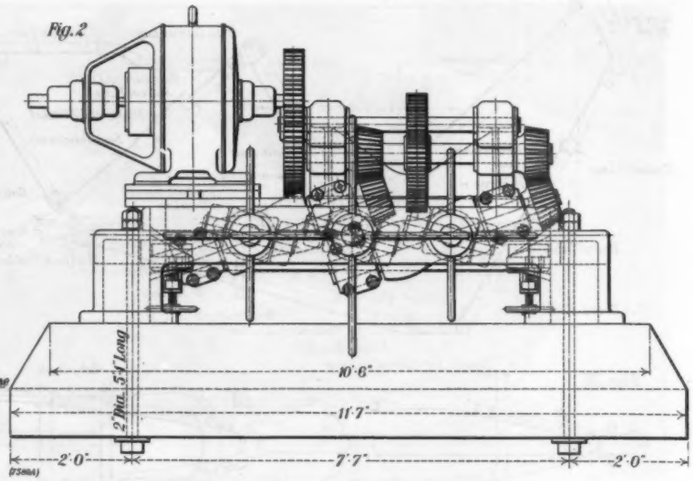


Fig. 2



composed of the thin wire on the cut-out, draws the contacts into position and the circuit through the main coil is completed and current flows through it to stud 4, and on through the battery, entering by the positive terminal. The return is established through the sheathing of the cable.

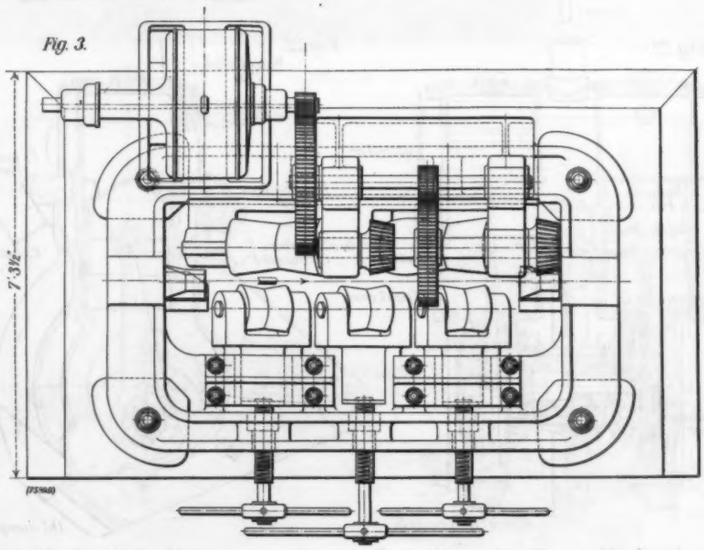
In the "lamps" position the switch connects the terminals of the switch-box marked 3 and 4, and current then passes from the battery through the lamps if the cycle is stopped or running slow, or from the generator when running fast. The path from the dynamo is seen to be from the positive brush to terminal 1 and on to the connection 5, at the switch, through the cut-out coils to the stud 4, which is connected by the switch to 3, thus bringing the lamps into action. The circuit from the dynamo is broken at the cut-out if there is too low a pressure generated, and the lamps then get their supply from the battery.

THE ABRAMSEN STRAIGHTENING MACHINE FOR ROUND BARS AND TUBES.

An interesting machine for straightening round bars and tubes which has recently been put on the market in this country by Messrs. J. Bigwood and Son, Limited, of Wolverhampton, is illustrated on this and the opposite pages. Messrs. Bigwood are the sole licensees and manufacturers of the machine, for England and the Colonies, with the exception of Canada. The machine, which is known as the Abramsen, is built in three sizes, of which we illustrate two, the medium-sized machine being illustrated in Figs. 1 to 4, annexed, and the smaller machine in Figs. 5 to 7, on page 737. At first sight, Figs. 4 and 7 may suggest a difference in type between the two, but the arrangement of the straightening rollers, except in point of size, is the same in the two machines, and the difference in appearance is merely a question of the arrangement of the driving gear. The machine illustrated in Figs. 1 to 4 will deal with bars from ⅜ in. to 3½ in. diameter and with tubes from 1 in. to 4 in. diameter, and the machine shown in Figs. 5 to 7 will deal with bars from ¼ in. to 1½ in. diameter, and with tubes from ½ in. to 4 in. in diameter. The larger machine, which we do not illustrate, is intended for bars from 3 in. to 6 in. in diameter, and for tubes from 4 in. to 12 in. in diameter, so that the range of three standard machines is from ¼ in. to 6 in. in diameter for bars and from ½ in. to 12 in. in diameter for tubes.

The straightening mechanism consists of two driving rolls, which are made from 0·3 carbon steel forgings and are of a form which can best be seen in Figs. 2, 5 and 6. These rolls are driven through machine-cut bevel and spur gears from a variable speed-reversing motor. The arrangement of the gearing in the two types of machine will be clearly seen in the figures. These driving rolls have their axes arranged at 20 deg. to the horizontal and consequently give a longitudinal as well as a rotary motion to the bar being treated, which is held firmly in contact with the driving rolls by three idle rolls. Two of the idle rolls are practically opposite the driving rolls and the other is midway between them. The idle rolls also have their axes

Fig. 3.



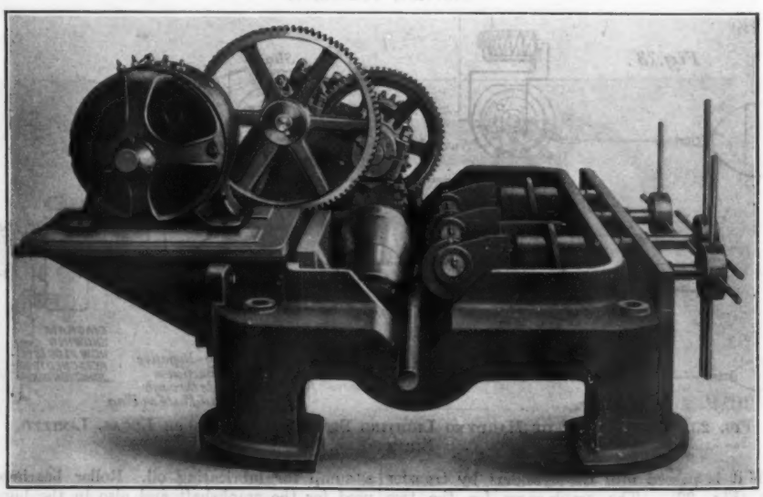


Fig. 4.

ABRAMSEN STRAIGHTENING MACHINES FOR BARS.

CONSTRUCTED BY MESSRS. J. BIGWOOD AND SON, LIMITED, ENGINEERS, WOLVERHAMPTON.

Fig. 5.

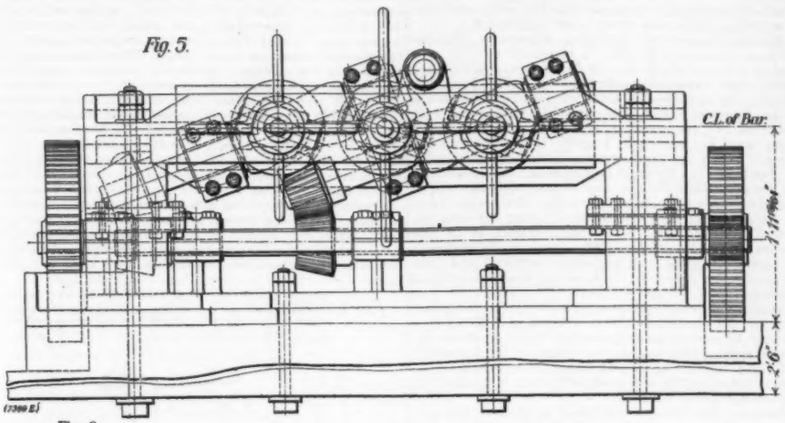
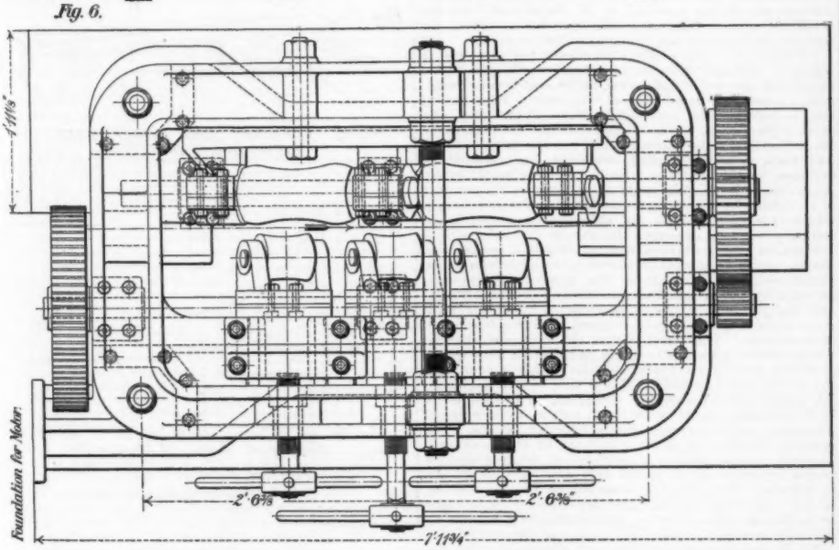


Fig. 6.



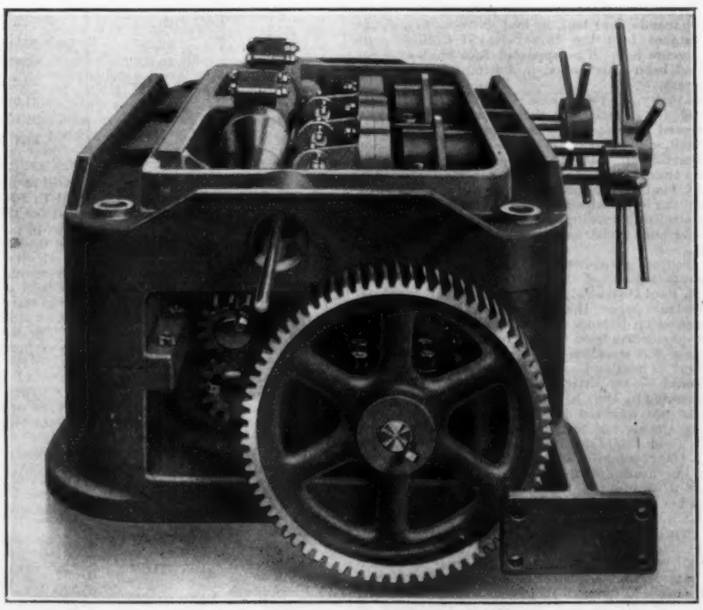


FIG. 7.

at 20 deg. to the horizontal, but inclined in the opposite direction from the driving rolls. When the machine is in operation a tube, or bar, entering it is gripped between the driving and idle rolls and is rotated and at the same time is drawn past the centre idle roll, which deflects it, the amount of pressure put on by this roll varying with the size of bar, and also with the thickness of wall in the case of tubes.

The rolls are made of such a contour that the bar makes line contact throughout the entire length of each roll. This eliminates the possibility of forming marks or spirals on the surface of the bar, and in the case of tubes of thin gauge affords support to prevent crushing. It is recognised that perfect line contact is not attainable with all diameters on the same rolls, but within the range of each machine the effect due to variation in diameter of the bar is found to be negligible in practice. This effect in any case concerns only the driving rolls, as the idle rolls may be swivelled and locked to lie accurately against any size of stock being operated on. The idle rolls may also be adjusted in or out, to suit the stock, by means of the star handles which can be seen in the figures. The idle rolls are phosphor-bronze bushed for all standard machines, but in the case of machines intended to deal with highly-polished tubes of light gauge they are provided with roller bearings.

The operation of the machine is very simple, the only adjustment being of the idle rolls, and when these have been set to suit the stock to be straightened no further adjustment of any part is required. The bars may then be entered as rapidly as the speed of the machine will permit and a continuous straightening process may be carried on at a speed of 25 ft. to 70 ft. per minute. When any particular stock is to be straightened the rolls are opened out so that the bar or tube can be pushed into the machine. The three idle rolls are then brought up against the bar. The motor is started in the reversed direction and the bar backed out until the front end of the bar is at the back of the centre idle roll. A turn is then given to the middle and end idle rolls, and the motor is started in the forward direction, when the machine straightens continuously for the same size of stock.

It is claimed that the machines will make any bar and tube, within the capacity of the machine, perfectly straight. The work is done in a single pass and is accurate on all grades of carbon or alloy steels, including high-speed tool steels either annealed or in the natural rolled condition. Bars are not only straightened but are improved in appearance, and in the case of annealed bars the straightening process gives a smooth and clean surface. The machines are suitable for butt and lap-welded tubes as well as solid-drawn, and also for brass, copper and other non-ferrous bars and tubes. The medium-sized machine, which we illustrate in Figs. 1 to 4, is driven by a 35 b.h.p. motor, and the smaller machine of Figs. 5 to 7 by a 20-b.h.p. motor. The larger machine which deals with bars up to 6 in. diameter and tubes up to 12 in. diameter requires a 74-b.h.p. motor. In its general design it follows the machine shown in Figs. 1 to 4. The Abramsen machines have been installed in many parts of the world and have been very successful in practice.

SAFES AND STRONG ROOMS.—Recent developments in the design and construction of safes and strong rooms, which we should imagine would dishearten the most scientifically-equipped burglar, were described in an exceptionally interesting lecture delivered at the Royal Society of Arts on Wednesday, the 6th inst., by Mr. Emory Chubb. The author referred to the fact that in modern safes the strongest plates were placed inside, where they were more difficult of access, instead of being used to form the exterior. The steel used, he said, was of a special alloy which offered the highest possible resistance both to drilling and to the action of the oxy-acetylene cutting flame. He also referred to the "crane hinge" for doors. With this arrangement, the doors are pivoted on four ball and roller bearings, two near the centre of the door and two at the edge, so that, in the final closing movement, the door enters straight into the frame instead of swinging round a vertical axis in the ordinary way. An airtight and watertight joint is obtained by this means. The doors of strong rooms, Mr. Chubb explained, were formed of hollow manganese steel castings machined and finished externally with great accuracy and filled to a thickness of about 16 in. with steel plates of different resisting properties; an electric screen is also fitted on the door to sound an alarm when penetrated by any means. The bolts of the door are controlled by combination locks, the mechanism of which the lecturer illustrated and described, as well as that of the time lock; the latter prevents the door from being opened by anyone within a certain time after shutting. For the walls of strong rooms, where space permits, the lecturer recommends the employment of an outer wall of blue Staffordshire bricks to protect an intermediate wall of "armed" concrete, with an inner compartment formed of tough steel, armour plate, or the special blow-pipe resisting alloy above referred to. Twisted bars of hard steel are used for armouring the concrete. At the conclusion of his lecture Mr. Chubb illustrated the manufacture of strong room doors of both circular and rectangular form by means of a cinematograph film.

PHYSICAL SOCIETY OF LONDON.

At the meeting of the Physical Society of London, held on November 24, at the Imperial College of Science, Alexander Russell, M.A., D.Sc., in the chair, (1) a paper on "*The Theory of the Singing Flame*" was read by Mr. E. G. Richardson, B.Sc. Of this paper the following is an abstract: The various theories of the action of the singing flame put forward since its discovery are reviewed, and experiments to test the relative merits of the two most recent theories are described; Lord Rayleigh's theory is shown to fit the results most closely, in that (1) heat is given by the flame to the air in the tube at each condensation, and (2) stationary waves are formed in the gas as well as in the air tube. But the lengths of gas tube unfavourable to the "singing" cover, in fact, a much more restricted range than Lord Rayleigh surmised.

Discussion.—Professor C. H. Lees (communicated): While the Rayleigh theory of the flame covers most of the observed facts and may be taken as satisfactory in its broad outlines, there are other facts which Mr. Richardson has brought to light with which it is not in complete accord. To cover these some modification of the theory will be necessary, but so far as I can see these modifications are not of a serious nature.

2. A paper on "*Unit Surfaces of Cooke and Tessar Photographic Lenses*" was read by Miss Alice Everett, M.A. Of this the following is an abstract: A number of rays in an axial plane (and a few general rays) are traced through the lens systems by exact methods, and on each ray the positions of the conjugate points for unit magnification are found by Mr. T. Smith's formulæ. The results show that for general rays the loci of these "unit points" are three-dimensional. The loci are surfaces only when the chief rays are bound by some condition such as passing through a fixed point of the object. In this case the unit surfaces are not fixed, but shift with the object point. The curvature varies with aperture, and with the distance of the object point from the optic axis. Hence the unit surfaces cannot coincide with wave-fronts. Within the region for which the lenses are designed, the curvature of both object and image unit-point loci is positive (convex to the light source) and the image loci is more curved than the object locus. These facts do not coincide with the theoretical conclusions obtained by Mr. Smith for either a thin system or an ideal thick system, but accord more nearly with the latter, especially as regards the sign of the difference of curvatures of the two unit surfaces.

3. A paper on "*Vibration Galvanometers with Asymmetric Moving Systems*," by R. Ll. Jones, M.A., was taken as read. In this paper the author stated that in the theory of the vibration galvanometer with 1 deg. of freedom certain specified conditions are assumed to hold. If these conditions are not satisfied in a galvanometer, the instrument will show multiple resonance. This indicates the need of a more general theory. The theory of vibrations of a system with 2 deg. of freedom is briefly given, expressions for the amplitudes of the forced vibrations are deduced, and the conditions for resonance ascertained. The results are applied to a galvanometer in which the moving system is asymmetrically hung on a laterally yielding axis, and it is shown that the formula for the amplitude is capable of reproducing with fair accuracy the sensitivity curve of the galvanometer, which shows multiple resonance. Asymmetry always lowers the sensitivity of the resonance, and the loss can be ascertained by the help of the sensitivity curve. The analogy to the vibrations in coupled circuits is pointed out.

The author desired to express his gratitude to A. Campbell for helpful criticism, advice and references.

4. *A Demonstration of Some Applications of the Gyroscope* was given by M. Paul Schilowsky, chairman of the Gyroscopic Society, Petrograd. M. Schilowsky said that the principles of the gyroscope are insufficiently taught in technical colleges, with the result that the subject has received very little attention from the engineering profession. Engineers are in consequence unduly sceptical as to the applicability of such principles to practical problems, although a staff of some 50 Russian experts under the speaker's chairmanship had evolved designs for the construction of a perfectly safe and practicable mono-rail system for a suburb of Petrograd. The models he was exhibiting were not to scale. In practice the gyrostatic apparatus would form from 3 per cent. to 5 per cent. of the load of a ship, and from 5 per cent. to 10 per cent. of the load of a mono-rail carriage. The underlying principle of his inventions is as follows: To stabilise a system in unstable equilibrium, a reaction must be set up between the system and the gyrostat of such a character as to help the precession of the gyrostat during the return of the system to normal. To check the oscillations of a stable system, the reaction must be such as to oppose such precession. The gyrostat must, of course, be power-driven to neutralise friction. The exhibits included the following:—

(*a*) A collection of apparatus for teaching purposes, comprising *inter alia* models illustrating the precession of the earth, a method of optically projecting an image of a spinning top, and small mono-rail models. The above-mentioned principle was illustrated by means of a top which, when spinning on a sharp point, exhibited precession. When, however, the point was furnished with a spherical knob, the top "slept" until its angular momentum was exhausted by friction, when it abruptly collapsed.

(*b*) Model of a rocking ship. The gyrostatic flywheel is mounted with its axle vertical in a frame, which can both rock about and slide along an axis transverse to the ship. When the ship rolls to starboard the axle of the wheel tilts in precession in a fore-and-aft plane, and at the same time the gyrostat slides bodily sideways under gravity, its frame engaging a rack which holds it with the axle in the tilted position. When the ship begins to roll back, the axle tries to reverse its fore-and-aft tilt, but is prevented by the engagement of the rack, which is spring-controlled. Thus precession is opposed during the return of the ship to normal and (the equilibrium being stable) rolling is checked by the resulting reaction.

(*c*) Model of an aeroplane carrying a gyrostat. The problem of combining automatic stability with mobility while avoiding dangerous stresses was discussed.

(*d*) Models of mono-rail gyrostatic apparatus. In the most recent design the flywheel is mounted with its axle vertical in a frame which can tilt in a fore-and-aft plane, and also slide sideways under gravity. The frame is surmounted by a pinion co-axial with and geared down from the flywheel; and the pinion lies between, but normally clear of, two parallel fixed racks mounted on the carriage, and having their lengths in a fore-and-aft direction. When the carriage tilts to one side, the axle of the flywheel tilts forward or backward in precession, and at the same time the gyrostat slides bodily sideways, so that the pinion engages one or other of the two fixed racks. The pinion then climbs back along the rack to its normal position, i.e., in the same direction as the precession which it would exhibit during the righting of the carriage. Thus such precession is aided and (the equilibrium being unstable) the resulting reaction restores the carriage to the upright position.

(*e*) Angular-velocity indicator for aeroplanes. Angular velocity of the aeroplane about a vertical axis causes a tendency to precess in a gyroscope rotating about an horizontal axis. This tendency is balanced by a gravity control, and the angle moved through in attaining a balance is indicated by a pointer, affording a measure of the required angular velocity.

Discussion.—Sir George Greenhill expressed the indebtedness of the meeting to M. Schilowsky for his brilliant experiments and address. He reserved for communication later any remarks he had to make.

Professor C. Vernon Boys expressed his pleasure at seeing a Russian scientist alive and well. He hoped M. Schilowsky would take back to his *confrères* in Petrograd a message of goodwill and sympathy. He admired the lecture-models, especially those illustrating the earth's precession. A mono-rail carriage for passengers seemed at first sight impracticable, but the designs which had been actually worked out must be accepted as evidence to the contrary. Such a system would effect great economies, and it would much improve the comfort of travelling by removing the constraint of a double rail, which is responsible for the shocks experienced in an ordinary railway carriage. In the long coach with a four-wheel bogey at each end, of which a model was shown, pitching as well as lateral movements should be eliminated. An example of the opposite extreme is afforded by the so-called mono-railway between Listowel and Ballybunion, which is mono-rail only in the Irish sense since it has five rails designed to give a maximum of constraint. The result is that the noise and shaking are excessive, a speed exceeding 15 miles an hour would probably destroy the track, and the design is such that the driver cannot cross from one side of the engine to the other without stopping the train. The designs of M. Schilowsky, on the other hand, aim at a minimum of constraint, with correspondingly superior results. The problem of replacing existing systems by the mono-rail, however, would involve questions of finance and of vested interests which would defy any calculus known to science. One difficulty occurred to him as serious. It was clear that the carriage would run on a straight or uniformly curved track; but what would happen in the case of a track whose curvature was changing?

Sir James Henderson expressed admiration for the experiments, and the skill and ingenuity of the practical designs. He fully agreed as to the necessity for educational propaganda, and had, in fact, introduced a course on the subject into the Royal Naval College some seventeen years ago. The apparent fact that a mono-railway had been constructed in Petrograd was one of much interest.

M. Schilowsky, in reply, said that no difficulty was experienced in negotiating short curves. (This fact was illustrated by means of a small model running on a curved track, and also on a turntable.) Long curves presented certain difficulties, which could not be discussed fully in the time available. In principle such difficulties are met by loading the instability of the system. Unfortunately the impression that the Russian Government had built a railway was imperfectly true. Some 10 km. of track had been constructed, but the scheme had got no further.

5. An account of a *New Balance for Compensating the Temperature Error of Watches and Chronometers* was given by M. Paul Ditisheim, La Chaux de Fonds (Switzerland). Of this paper the following is an abstract: The compensation balance made from a bimetallic rim cut in two places has been for nearly 200 years the only method used for equalising the rate of watches and chronometers in heat and cold. An entirely new system is now offered by the hair-spring made of "Elinvar," an alloy invented by Dr. Ch. Ed. Guillaume, the elasticity of which is not affected by changes of temperature. Satisfactory timing can thus be obtained up to certain limits with a plain solid uncut balance. This metallurgic solution of the problem of compensation at all temperatures is an important step in the history of watchmaking.

In order to apply the "Elinvar spring" to higher grade watches a new compensation balance has been designed by M. Ditisheim. It is made from a plain monometallic uncut ring into which two very small symmetrical bimetallic blades are inserted. The latter will enable small corrections to be made in order to obtain very fine rates. This adjustment is necessary for compensating small differences between springs resulting from molecular change and mechanical treatment in their manufacture.

"DOUBLE REDUCTION GEARS FOR TURBINES."

To the Editor of Engineering.

Sir,—The correspondence columns of your journal have of late contained letters dealing with the question of the failure of reduction gearing pinions, and it will, therefore, probably be of interest to readers to consider the following experiments, for which we have devised a new form of test which may be described as the uni-directional repeated blow test. When discussing the possibility of fatigue fractures without appreciable deformation (arising from a case of fractured pinion teeth), it is to be noted that whilst fracture without deformation is clearly understood to be possible in the case of alternating stress, cases of similar fractures are the rule in teeth where, generally speaking, the stress is in one direction only. I have had one example before me where the teeth were rupturing from both sides simultaneously, but it is agreed that that particular instance is not typical of the failure of reduction gearing teeth. It has been stated, and indeed the view is largely held, that the injury of a tooth by relatively light hammering action in one direction only will not produce fracture, but experiments to be described later will show

Fig. 1.

Fig. 2.

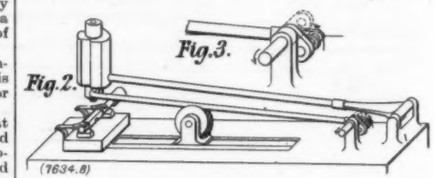
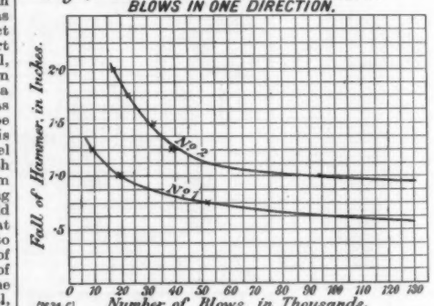


Fig. 4. REPEATED BLOW IMPACT TESTS. BLOWS IN ONE DIRECTION.



Fall of Hammer.	Number of Blows to Fracture.	
	No. 1.	No. 2.
in.		
½	166,254	—
¾	52,257	1,000,000 unbroken.
1	18,820	94,630
1¼	8,954	39,218
1½	—	31,910
1¾	—	22,644
2	—	17,458

that such uni-directional hammering will readily produce fractures analogous to those observed in broken teeth. Fig. 1 is a drawing of a test-piece used for these experiments, and it will be seen that the bar-piece is of rectangular section with the notch on the underside in the form of a circular groove, the radius of which corresponds to the radius at the bottom of the teeth in some examples of pinions. The test-piece is securely held at each end on good foundations, and the blow used in the experiment is struck by a hammer weighing 4·7 lb. at a speed giving approximately 90 blows per minute. The whole of the apparatus is illustrated in Fig. 2, an important detail being shown on a larger scale in Fig. 3.

Before settling upon a definite form of notch and conditions of test, a number of experiments were performed which gave very definite evidence of failure, as above described, and quite in line with the two complete sets of data referred to later.

The two steels selected for the investigation were of the composition shown in the following table:—

	Carbon Steel.	3 Per Cent. Nickel Steel.
Carbon	0·40	0·44
Manganese	0·70	0·59
Silicon	0·19	0·17
Sulphur	0·037	0·035
Phosphorus	0·025	0·027
Nickel	0·15	2·75
Chromium	Nil	Nil

The carbon steel had been normalised at 875 deg. C., and had a Brinell hardness number of 163. The nickel steel had been oil-hardened from 850 deg. C. and tempered to 630 deg. C., giving a Brinell hardness number of 238. In estimating the stresses produced in these tests one meets a very definite difficulty. Some unknown portion of the energy of the blow is dissipated in the machine and its foundations. Further, the law between deflection and stress cannot be assumed beyond the limit of proportionality. It is, therefore, not intended to give here any complete estimate of the stresses set up at the bottom of the notch under the conditions of the experiment. It is sufficient to give data for those interested to attempt the calculations for themselves. It is obvious that calculated stresses are very much above the real stresses set up. When the stresses exceed the elastic limit the laws assumed in the calculation do not apply. If the energy of an impact has to be absorbed by elastic deformation only, it is surprising what high stresses are induced by an apparently small amount of kinetic energy. This remark has probably a good deal of bearing on the gearing trouble. It is of interest to note that under conditions of the experiment, the hammer falling 0·1 in. produces a stress of about 18 tons per square inch, providing that the steel behaves in a truly elastic manner, and that the incidental losses of energy are negligible. The two steels under test gave the figures shown in the table reproduced under the diagram, Fig. 4.

It is clear from these experiments that a hammering effect in one direction unquestionably may result in a smashing of perfectly good material.

Yours faithfully,

W. H. HATFIELD.

The Brown-Firth Research Laboratory, Princess-street, Sheffield, December 8, 1922.

TO THE EDITOR OF ENGINEERING.

SIR,—Having been abroad I have only to-day noticed the reply of Mr. T. M. Service to my letter on the above subject, published in yours of the 10th ultimo.

I can produce the drawings and technical data connected with the various vessels to which I referred when I wrote, but I cannot possibly meet Mr. Service's challenge to estimate the stresses to which gears are subjected under sea-going conditions, particularly should any heavy obstruction foul the propellers, to name but one example. The conditions under which the gears are operating at sea are so varied in their nature that the stresses produced in the worst cases may be said to be almost incalculable.

It is, however, possible to estimate the designed stresses, assuming fixed conditions, and in general terms I think engineers, by the use of a generous factor of safety, endeavour to produce a gear which, barring accidents, will stand up to ordinary sea-going work.

I should, however, be glad if Mr. Service would try to explain (by a scientific investigation of the steel used), the fact upon which I laid most stress, namely, that the majority of pinions made prior to 1919 have not failed by fracture of the teeth, while a very great proportion of those manufactured after this date have failed.

Yours faithfully,

R. R. GRAY CHISHOLM.

"THE THEORY OF THE AIRSCREW."

TO THE EDITOR OF ENGINEERING.

SIR,—Since the paper on the above subject, referred to in your issue of the 10th ultimo, on page 593, was read at the Royal Aeronautical Society, a technical discussion has been held by the Society, at which Mr. Relf quoted measurements made at the National Physical Laboratory of the circulation defined by the equation $\kappa = \int u\,ds$ *i.e.*, circulation = integral of velocity resolved along the tangent to a closed circuit, taken round various circuits enclosing a wing.

The figures were in most satisfactory agreement with the circulation calculated from the observed lift by means of the relation $L = \rho \kappa U$, *i.e.*, lift = density × circulation × velocity at a distance. Although entirely to be expected, this was none the less a very important independent confirmation, and led Professor Bairstow to state that his views must be shaped accordingly. We may therefore take the existence of circulation round an aerofoil for granted and turn to the outstanding question how an aerofoil, by its shape alone, produces circulation, in contrast with a golf ball, for example, which produces circulation by the almost obvious mechanism of spin and surface friction.

Fig. 1 shows irrotational flow past an aerofoil, and is Joukowsky's transformation of flow past a circular cylinder. (Lamb's "Hydrodynamics," fourth edition, page 75.) Fig. 2 shows circulation round an aerofoil obtained by the same transformation from circulation (with logarithmic velocity potential), round a circular cylinder. Fig. 3 shows the result of superposing these velocity fields, when the velocity and intensity of circulation are chosen so that the discontinuity at the rear tip of the aerofoil just disappears. The pressure distribution under this ingenious assumption follows closely the observed distribution in form, but is everywhere too great in about the ratio 4 : 3. We may assume that the configuration of flow is given pretty correctly, but that the numerical value of the circulation is too high. The existence of a small, highly-irregular pressure region at the rear edge is also confirmation that the Joukowsky value of the circulation is not reached.

Fig. 4 illustrates Helmholz flow with sheets of separation between stream and dead water. The configuration of the flow corresponds to zero pressure on the upper surface, and the calculated lift is about one-third of the observed lift, at small incidences. Fig. 5 illustrates certain observed facts. Along the lower face, a vortex sheet begins to form at the leading edge, and as it passes along the surface the elements coalesce into finite eddies forming a belt that grows pretty uniformly in depth towards the trailing edge. At any instant this row of eddies may be considered as in equilibrium with its image in the surface. At the surface, no slip may be assumed. As the belt passes beyond the surface, equilibrium is no longer maintained and eddies of much wider spacing are thrown off periodically.

At the upper surface, a Helmholz sheet of separation begins to form, but as it is in physical fact a vortex sheet, it curls in on itself. The subsequent behaviour is

Fig.1.

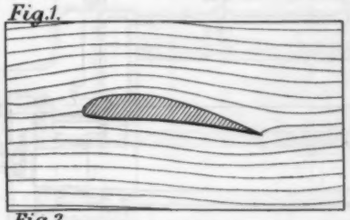


Fig.2.

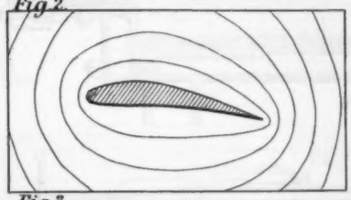
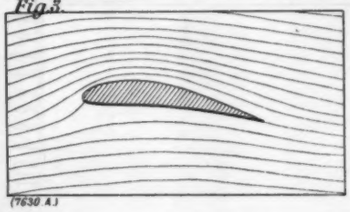


Fig.3.



(7630 A.)

Fig.4.

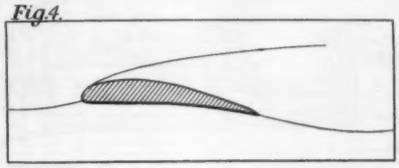
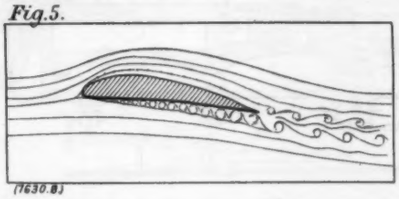
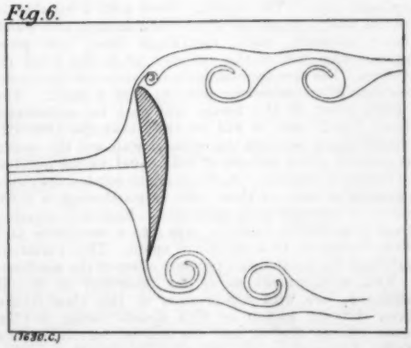


Fig.5.



(7630 B.)

Fig.6.



(7630 C.)

strikingly different according as the incidence is above or below the so-called critical or "stalling" incidence. Below stalling incidence, the sheet, curling closely round the upper surface, seems to come into a position of equilibrium with its own image in the surface, until it passes beyond the trailing tip, where being no longer maintained in equilibrium by its image, it breaks up periodically into eddies. Above the stalling incidence, the Helmholtz vortex sheet breaks up into eddies in characteristic fashion, before it can curl in sufficiently to reach a position of equilibrium with its image in the now more distant surface.

Below stalling incidence the configuration of the flow follows closely the outline of the wing, and therefore resembles fairly closely the configuration of irrotational flow, and, in consequence, of Joukowsky flow. Again, it is quite in accordance with our knowledge of fluid resistance to suppose that the resistance of the lower surface in direct contact with the stream should be greater than that of the upper surface which is separated by a belt of fluid and by the vortex sheet from the stream. But if this is not admitted from previous knowledge we should be led to infer it now from the existence of circulation. It also follows that the strength of the eddies shed along the trailing edge is greater at the lower surface than at the upper. Once shed, these eddies rapidly cease to have any serious influence on the flow round the wing, and are chiefly effective in maintaining a wake of reduced velocity far down stream. They are an effect rather than a cause of the process of setting up circulation, but they may be a fundamental measure of its intensity.

Altogether it seems somewhat fortuitous that the modification of the pure Helmholz flow is in the direction of the Joukowsky flow at small incidences. As the former gives about one-third and the latter about four-thirds of the observed lift and circulation, it is obvious that any intermediate state will not be wildly wrong. Beyond stalling incidence, the pure Helmholz flow rapidly approximates to the observed flow (Fig. 6), the calculated reaction being only about 30 per cent. in defect soon after stalling, and only 20 per cent. in defect at 90 deg. The breakdown of the vortex sheets into periodic eddies reduces the pressure on the rear surface and accounts for the remaining 20 per cent. reaction. In passing, it is obvious that the curling in of the vortex sheet at small incidences corresponds to reduction of pressure on the upper surface, but this is only another way of looking at the effects of circulation.

From these considerations, the writer questions whether the success of Joukowsky's assumption that circulation is determined in intensity simply by the disappearance of the discontinuity round the trailing edge is more than a happy accident. The actual mechanism by which circulation is produced seems to be much more involved, and to depend on conditions along the wing surface, though the flow as a whole is very sensitive to alterations of shape at the rear edge. Above stalling incidence the flow moves back towards the pure Helmholz type, modified by periodic formation of eddies and the Joukowsky flow no longer approximates even faintly to the actual configuration.

Yours truly,

London, December 6, 1922. A. R. LOW.

WERKSPOOR MARINE DIESEL ENGINES.—From a pamphlet which has reached us from Messrs. Werkspoor, of Amsterdam, we gather that there are now in service 23 motorships propelled by Diesel engines of over 1,000 b.h.p. designed by that firm, who have also constructed engines of the same type for 18 smaller vessels. Another pamphlet also to hand gives some interesting particulars of the results obtained with the motorship Vulcanus. This vessel, which was the first sea-going vessel to be propelled by a Diesel engine, was fitted with a Werkspoor engine developing 480 s.h.p. and put into service at the end of 1910. From that time to January of this year she had covered a total distance of nearly 310,000 miles at an average speed of 6·26 knots, and with an average daily fuel consumption of 1·679 tons. A considerable improvement in the fuel consumption seems to have been effected during this period of service, since we notice that the daily consumption in 1912, when the vessel travelled 22,200 miles at an average speed of 6·75 knots, was 2·048 tons, while that for 1921, when the vessel covered 24,180 miles at a mean speed of 6·787 knots, was only 1·607 tons. We do not know to what extent the difference may be due to the use of a better quality of fuel. The Vulcanus, we may add, is an oil tanker owned by the Anglo-Saxon Petroleum Company, with a length of 196 ft., a breadth of 37 ft. 7 in. and a draught of 13 ft. 2 in. Her displacement loaded is 2,080 tons, and deadweight capacity 1,200 tons. She has been employed entirely in Far-Eastern waters, where no exceptional facilities for repairs exist.

GOVERNMENT WOOL DISINFECTING STATION AT LIVERPOOL.—In connection with the working of the Anthrax Prevention Act of 1919, a wool disinfecting station has been erected at Liverpool, which has an output of about 40,000 lb. of wool per week. The handling of the material is automatic throughout. The pressed bales as received are placed on a moving platform which carries them to a feeding and opening machine when stripped of the bands and covers. The opened material is fed next to a machine in which it is subjected to a dilute alkaline solution at 102 deg. Fahr., after which it is squeezed and delivered to one in which the treatment is by dilute alkaline soap solution at 102 deg. Fahr., in two successive baths. Passing through rollers, it then enters the actual disinfecting machine, in which it is passed through two baths of 2·3 per cent. solution of formaldehyde at a temperature of 106 deg. Fahr. Subsequent to this, after again passing through rollers, it is blown by air into a drying machine, whence it is discharged to a cooling machine. From here it is blown into a charging box for a baling press and is made up into pressed bales weighing 320 lb. The wool remains ten minutes in each bath, and twenty minutes in the drier and cooler, the whole process occupying about one and a-half hours. Handling the material itself is completely obviated, but the workmen are safeguarded in every possible way. When entering the disinfecting machines the men wear box respirators filled with charcoal. The drying machine is furnished with a fan to prevent the escape of formaldehyde vapour into the room, while the dust from the raw material is conveyed pneumatically to the boiler furnaces direct.

ROTARY AIR COMPRESSORS.

CONSTRUCTED BY THE SWISS LOCOMOTIVE AND MACHINE WORKS, ENGINEERS, WINTERTHUR, SWITZERLAND.

Fig. 1.

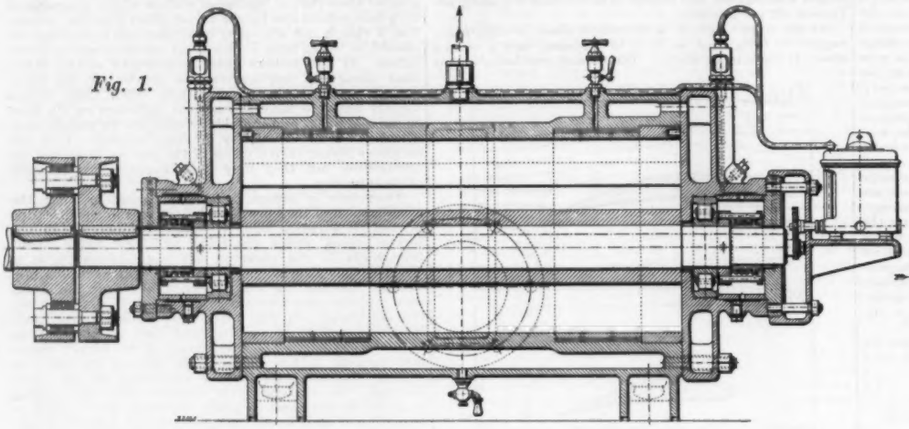


Fig. 2.

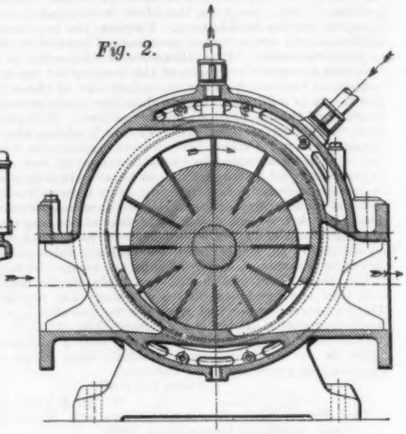


Fig. 3.

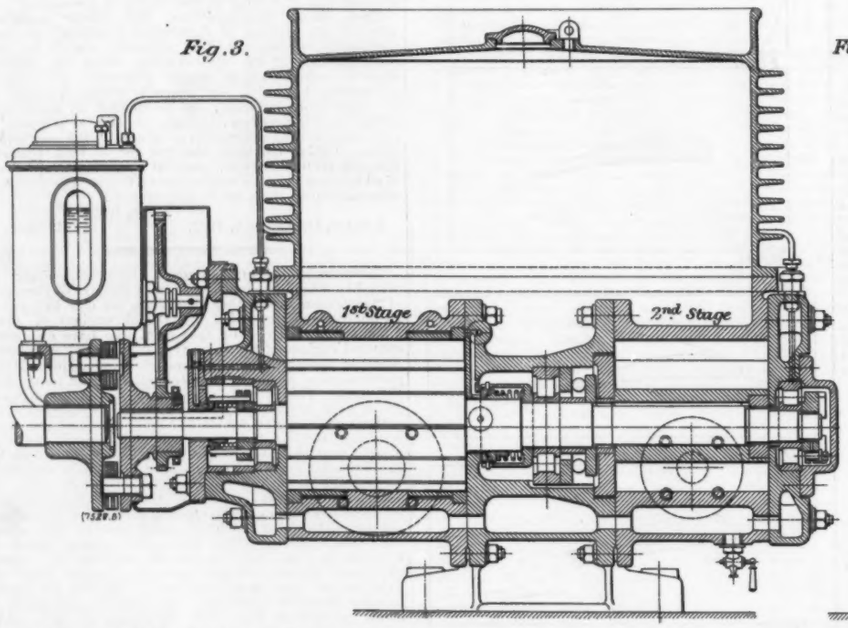
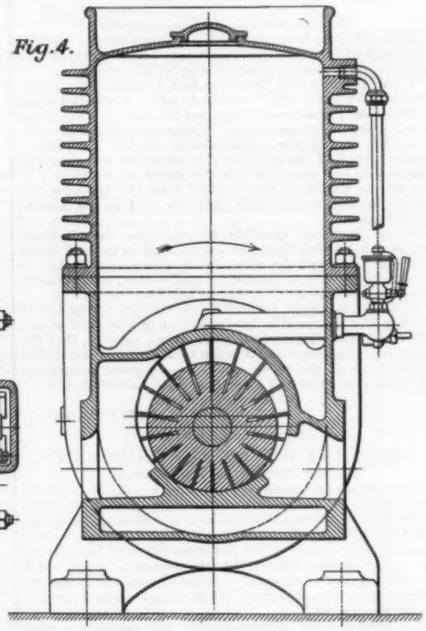


Fig. 4.



At the present time there is a tendency in machine design towards the adoption of purely rotary mechanisms as against those involving reciprocating main parts. This tendency is connected with the general adoption of higher running speeds which has followed improvements in materials and machining methods, and may also be associated with the development of the electric motor. One of the fields in which this tendency may be seen is in the development of air compressors. Both the turbo-compressor and the rotary compressor have received much attention during recent years, and for large capacities and relatively low pressures the former has taken a position of great importance. The rotary compressor has been developed for smaller capacities and higher pressures.

The reciprocating compressor is, in general, an entirely satisfactory article, but does not usually lend itself well to direct coupling to an electric motor, while for some services the pulsating delivery is not in its favour, and the expense of the plant has to be increased by the installation of air vessels. The rotary air compressor is, of course, a type of machine of long standing, but like other mechanisms has developed in recent years, and the new compressors which are being introduced by the Swiss Locomotive and Machine Works, of Winterthur, Switzerland, will be found of much interest. The British representatives of the firm are Messrs. Bernard Holland and Co., of 17, Victoria-street, Westminster. Various patterns and applications of the compressor are illustrated in Figs. 1 to 13 above, and on pages 741 and 744.

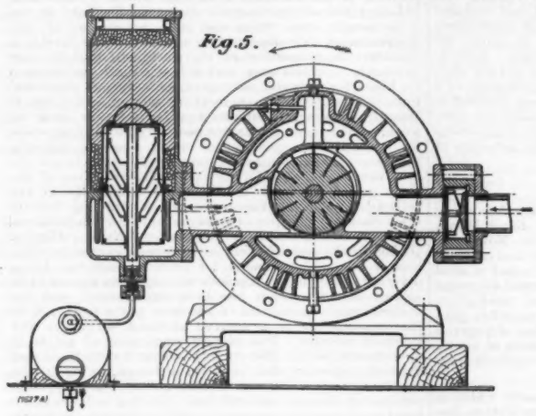
The machine consists essentially of a horizontal cylinder with a rotor mounted eccentrically to the cylinder bore. The rotor is fitted with a number of radial blades, or slides, which work in slots and which move outward, under centrifugal force, and press against the wall of the cylinder, when the rotor revolves. The arrangement is clearly shown in the cross-sections of a compressor given in Figs. 1 and 2. The arrangement of the blades will best be understood from Fig. 2, and it will be clear that the crescent-shaped space between the cylinder wall and the casing is divided into a number of cells equal to the number of blades in the rotor. As the machine rotates, the cubic capacity of each of these cells varies through a cycle which is repeated each revolution. Each cell, starting from a minimum capacity, grows to a maximum and then decreased to a minimum again. This variation produces the suction and pressure effect of the machine.

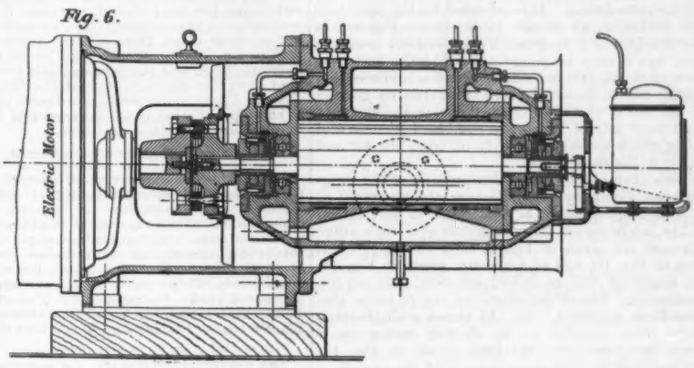
This arrangement as so far described is of old standing, but with compressors of this class it has been difficult to run at high speeds owing to the wear of the blades, and the special feature of the Swiss Locomotive and Machine Works compressor, with which we are now concerned, lies in the introduction of a pair of floating rings carried in the cylinder. These rings are clearly shown in Fig. 1. The use of these rings very greatly diminishes the friction of the blades against the cylinder walls and allows an increase in peripheral speed of the rotor to about one and a half times without producing any appreciable wear. For the same number of revolutions per minute this permissible increase in peripheral speed allows an increase in diameter to one and a half times, which gives an increase in capacity of $1 \cdot 5^2$ or 2·25. If the diameter remains unaltered the floating ring construction allows the number of revolutions to be raised and, depending on the size, compressors of this type may be run at from 500 to 3,000 revolutions a minute. As will be clear from Figs. 1 and 2, the machines have no valves, which often are a source of trouble in many air compressors. They give a constant flow of air without pulsations and the pressure is independent of the speed. In this latter respect they have an advantage over turbo-compressors.

The Swiss Locomotive Company secured a patent covering these floating rings in 1914, and since then have built a large number of compressors of various types embodying the principle. In general, the rotor is made of cast iron and the main shaft is carried in roller bearings. These can be seen in the machine illustrated in Figs. 1 and 2, and also in the two-stage compressor shown in Figs. 3 and 4. For smaller machines ball bearings are used, as shown in the rotary vacuum pump which is illustrated in Figs. 5 and 6. The blades, which are made as thin and light as possible, are of hard sheet steel. The number fitted varies with the size of the machine and the pressure to be produced. The floating rings require great care in manufacture. The inner diameter is made somewhat smaller than that of the cylinder after taking into consideration elastic deformation due to centrifugal stresses and heat effects. The actual best relative internal diameters of the rings and the cylinder have been determined only by experience. The problem is, of course, to reduce friction as much as possible and at the same time to ensure an adequately airtight joint between neighbouring cells. The floating rings have to move easily and are consequently made with a clearance

ROTARY AIR COMPRESSORS.

CONSTRUCTED BY THE SWISS LOCOMOTIVE AND MACHINE WORKS, ENGINEERS, WINTERTHUR, SWITZERLAND.





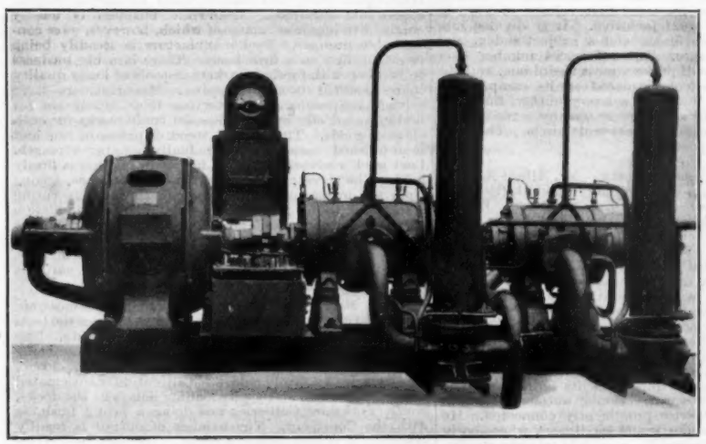


FIG. 7. SEMI-PORTABLE TWO-STAGE COMPRESSOR.

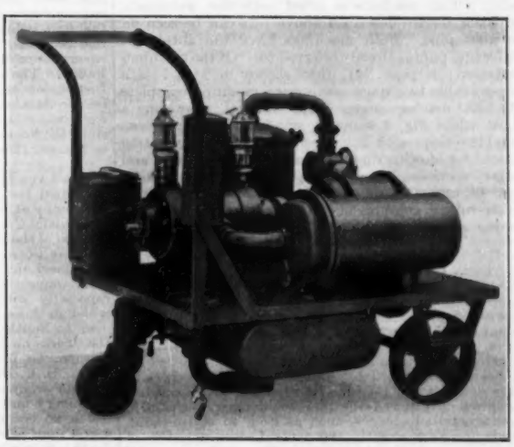
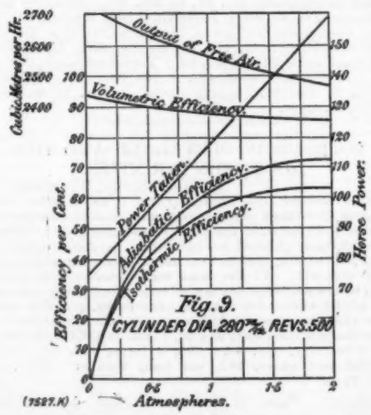
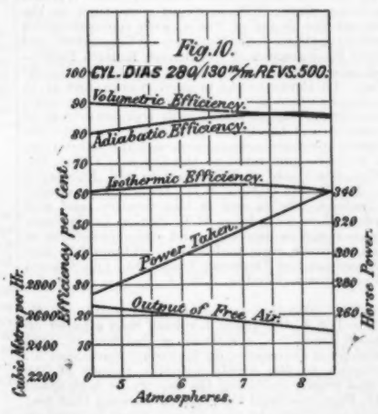
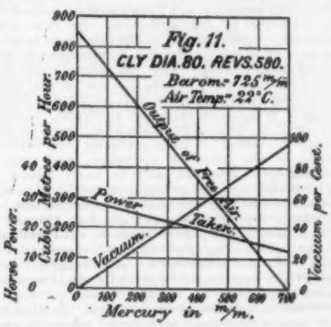


FIG. 8. SMALL PORTABLE COMPRESSOR FOR DUST-BLOWING.







on the outer diameter. To prevent leakage of air through this clearance a series of small blades fitted in grooves are fixed on the floating rings, and a balance of pressure between the inner and outer parts of the rings is obtained by means of small holes pierced through the rings.

The ends of the cylinder are closed by cast-iron covers which leave a slight clearance for the expansion of the rotor. This clearance is made very small in order to avoid loss of air and allow maximum efficiency to be obtained. The bearings which are carried in the covers have, of course, to be made of sufficient dimensions to carry the differences in pressure between the suction and delivery sides of the rotor. The stuffing-boxes have metallic packing. As will be seen from the figures the cylinder and cylinder covers are water-jacketed. When the service required is intermittent only a water hopper arrangement may be used, as shown in Figs. 3 and 4, but for continuous service the circulating arrangement of Figs. 1 and 2 is to be preferred. The pressure developed by any machine depends on the point in each revolution at which each cell is opened to exhaust. As will be clear from Fig. 2, this depends on the formation of the cylinder wall. For best efficiency the machine should be built for the pressure at which it is to work, but lower pressures than the maximum can be obtained by throttling the suction. The power required to drive the machine will not, however, diminish in proportion to the fall in pressure generated.

For use in situations in which the air consumption is variable, a simple automatic regulating device has been designed for use in connection with these machines. This shuts the inlet valve as soon as the delivery pressure rises above normal. The inlet valve is of the piston type, and at the moment when it closes a second smaller valve opens and relieves the pressure on the discharge side of the compressor. A back pressure valve is interposed at the connection between the discharge side of the compressor and the delivery pipe, so that the operation of this small valve does not discharge the main pressure line. The pressure side of the compressor is thus put to atmosphere, and a vacuum is created on the suction side. This reduces the power required for driving by about 20 per cent., When the pressure in the discharge pipe falls below a fixed point the piston valve opens again and the smaller valve closes so that the machine takes up its load again.

In rotary compressors, as in reciprocating compressors, the pressure which may be commercially obtained in a single stage is limited by the heat generated and by air losses. In practice the limit is found to be in the neighbourhood of 60 lb. per square inch. In the case of pumps a vacuum of about 95 per cent. is the limit for a single stage. By compounding

Over

these figures may be greatly exceeded, and two-stage machines are built to give pressures up to 230 lb. per square inch. With three-stage machines this pressure may be exceeded. With vacuum pumps a two-stage machine has given an absolute pressure of 0·25 mm. of mercury. The machine shown in Figs. 5 and 6 is a rotary vacuum pump with an electric motor built on to the same frame. It is intended for the operation of the brakes on an electric locomotive. The details of the machine will be generally understood from the figures, but it may be pointed out that the fitting to be seen at the right-hand side of Fig. 6 is a lubricating oil pump which, as will be seen, is driven by gearing from the end of the main shaft. The arrangement at the left-hand side of Fig. 5 is a combined silencer and oil filter which collects any dirty oil from the air and drains it to the tank below.

Various examples of rotary compressors of the Swiss Locomotive Company's manufacture are illustrated in Figs. 7 and 8, on page 741, and Figs. 12 and 13, on page 744, while curves of performance of a single-stage compressor are given in Fig. 9, of a two-stage compressor in Fig. 10, and of a vacuum pump in Fig. 11. These diagrams will be self-explanatory and require no comment. The illustrations of compressors also require little comment. Fig. 12 shows a single-stage machine direct-coupled to an electric motor on a common bedplate. The machine shown in Fig. 13, which is coupled in the same way, is of the two-stage type, the two stages being contained in a single casing. This machine is fitted with the automatic regulating device described above. It can be seen on the inlet pipe. Both machines have the automatic lubricating pump, already referred to. Of the machines illustrated on page 741, that shown in Fig. 7 is a semi-portable two-stage compressor mounted complete with its driving motor and control gear on a frame, while Fig. 8 shows a small electrically-driven portable compressor intended for use in generating stations for blowing dust from electrical machinery and similar services. Our two remaining illustrations, Figs. 14 and 15, on page 744, show petrol engine driven rotary compressors mounted on vehicles and forming self-contained travelling plants.

THE ATOMIC PROCESS IN MAGNETISATION.

On Monday, the 4th inst., Principal Sir Alfred Ewing made, to the Royal Society of Edinburgh, a communication on the atomic process in magnetisation. This was a development and modification of ideas, some of which had been put forward by him in 1890, and others in papers recently published. In these he had described models which allowed the process of magnetisation in ferromagnetic substances, such as iron, to be imitated, reproducing very exactly the general characteristics of the process, including hysteresis. The chief purpose of the present communication was to describe a modified form of model which not only reproduced the distinctive features of ferromagnetism, but also those exhibited by paramagnetic substances, Taken in conjunction with Langevin's theory of diamagnetism, the new model appeared to offer a general clue to the process of magnetisation in any solid body, whether ferromagnetic, paramagnetic, or diamagnetic. Any such conceptions, however, were necessarily tentative, in view of the incompleteness of our knowledge of atomic structure. It was now generally recognised that the electrons, in consequence of orbital motion or otherwise, were in some way magnetic di-poles. If their grouping were perfectly symmetrical in the atom or molecule, there was no resultant magnetic moment, and in cases where the grouping might be regarded as rigid, the application of an external magnetic field produced only diamagnetism. If, however, the grouping were not rigid but allowed individual electrons to have their magnetic axes reversibly deflected against a strong controlling force, we found the phenomena of paramagnetism. As regards ferromagnetism, the group might be initially unsymmetrical, having a resultant moment, so that it could serve as the Weber element in a ferromagnetic process. In that case the phenomena of hysteresis were found when the group as a whole turned from one position of stability to another. The control under which such irreversible turning took place was probably to be looked for partly in the mutual action between the outer shell of electrons of any one atom and those of its next neighbours in the space-lattice, as well as in the mutual action from atom to atom of the groups which constituted the Weber elements, as in the author's model of 1890. The magnetic axes of the groups tended to orient themselves in rows. In the initial stage of the ferromagnetic process, the group of electrons in each atom was deflected reversibly through a small range, after which there was a break away, and new rows were formed with a more favourable orientation. The control which caused the range of reversible deflection to be very narrow (as, for example, in iron) he now ascribed to the forces (not exclusively magnetic) between juxtaposed electrons in the outer shells of atoms which were contiguous in the space lattice. The contiguous atoms were to be regarded as turning simultaneously under the influence of the applied field, first reversibly through a small angle, and then irreversibly into new lines, which, in an iron crystal, would be inclined at 90 deg. or 180 deg. to the old ones.

When all the groups were turned in one direction by applying a sufficiently strong external field, the magnetism was what was called saturated, but according to the author's view, there might even then be a further increase of the magnetism through the reversible turning of the individual electron axes within any group. The externally-applied field also necessarily caused some diamagnetic action. For both of these reasons the moment of the group constituting the Weber element was not constant. The ultimate result of indefinitely increasing the field should therefore be to cause the magnetism of the substance to pass a maximum. According to these ideas, three distinct types of action were produced in a ferromagnetic solid by the application of a magnetic field, and the paramagnetic process differed in kind from the diagmanetic and the ferromagnetic processes. The author proceeded to discuss these suggestions in the light of what is known regarding the influence of temperature and other conditions.

British Iron and Steel Production.—According to the National Federation of Iron and Steel Manufacturers, the production of pig-iron in November amounted to 493,900 tons and of steel ingots and castings to 600,800 tons. In the case both of pig-iron and of steel this is the highest total attained since the coal stoppage of 1921. In the case of pig-iron, however, production is still only 57 per cent. of the average monthly production of 1913. Included in the production of pig-iron were 148,600 tons of hematite, 145,000 tons of basic, 134,900 tons of foundry and 33,100 tons of forge pig-iron.

The Institute of Metals.—A very valuable addition to the proceedings of this most active Institution has now been issued in the shape of an index to its first twenty-five volumes, from the first volume of 1909 to the first volume of 1921 inclusive. It is divided into two sections, a name index and a subject index, and covers over 490 pages. The references number over 20,000. The book will prove a most useful one, and the Institution is to be congratulated on its compilation. Its production has involved a heavy outlay, but this, we trust, will be offset to some extent by a ready sale, since the book appeals to a very wide circle. The price is 25*s.* net (25*s.* 9*d.* post free).

The late Mr. Albert Aichele.—Mr. Albert Aichele, who died last month, was for more than thirty years a prominent member of the firm of Messrs. Brown, Boveri and Co., of Baden, Switzerland, and during a long portion of that period electrotechnical director of the firm. Born at Lörrach in 1865 he was educated at Lausanne and Basel and studied at Zürich, and later at München. First connected with the Maschinenfabrik Oerlikon, and especially with the winding department of that firm, which in those days was the envy of competitors, he went over to South America to supervise his firm's share in the work on the Transandine railway. Returning to Europe, he joined the Baden firm, being a friend of Mr. C. E. L. Brown, as chief of the testing department. Aichele originated many improvements both in electric machinery and in the construction of automobiles, with which he became likewise prominently connected. He was a man of rare modesty and kindliness, whose early death is very widely regretted; a weak heart put a sudden end to his life.

British Empire Exhibition Inquiry.—Sir William Joynson-Hicks, Bart., M.P., arranged a meeting, on the 11th inst., at the Board of Trade, with representatives of the Executive Council, the Management Committee, and the General Management of the British Empire Exhibition, and also High Commissioners for the Dominions and India. An inquiry is to proceed at once, and is to consider, among other points, what steps are being taken to provide for full consultation with representatives of the Dominions and the Colonies in order to secure the use of Imperial produce in connection with the Exhibition. A report is to be presented to the Colonial Office, the India Office, the Board of Trade and to the Executive Council. Mr. R. W. Dalton, H.M. Trade Commissioner in New Zealand, who is now in this country, and will shortly proceed to Canada as H.M. Senior Trade Commissioner, will act as secretary, and communications in connection with the inquiry should be addressed to him at the Department of Overseas Trade, 35, Old Queen-street, Westminster, London, S.W. 1.

Birmingham Metallurgical Society.—Mr. A. R. Page, of the B.S.A. Company, Limited, read a paper on "High-speed Steels" at a meeting of this Society, held at the Chamber of Commerce, on Thursday, November 30. After referring to the highly complex nature of the subject, and briefly outlining the history of high-speed steels, Mr. Page reviewed the various theories that had been advanced during the past twenty years in order to explain the properties of these steels, and summed up existing knowledge of the matter. The important subject of hardening and tempering high-speed steels was dealt with in detail, and attention called to the great care necessary for their successful heat treatment. It was stated that ideal hardening produced a steel showing under the microscope a small-grained polygonal structure possessing an austenitic appearance. The effect of tempering was shown and reference made to the phenomenon of "secondary hardening." The author pointed out that there was very great need for some simple test whereby tools could be checked, in order to be sure that the best treatment had been successfully carried out, and that the cutting properties of the steel were satisfactory. In this connection file and Brinell hardness tests were often misleading and bore little or no relationship to the cutting properties. Mechanical methods of testing, notably drilling tests, were also dealt with by the author.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—The Government's decision to lay down two capital ships has cleared the air as far as the position of the Sheffield armament works is concerned. Whether the contracts come direct to Sheffield or not it is certain that, from the close association of this district with the shipbuilding centres in the North, a considerable proportion of the work will find its way indirectly into this area, and will stimulate the demand for heavy forgings and castings, machinery, and engineers' tools. In the purely engineering section, optimism is steadily growing. Inquiries tend to increase week by week. Apart from the urgent necessity for placing orders for renewals, the prospect of rising prices is inducing consumers to come forward more freely so as to get the best terms available for forward delivery. One of the most gratifying signs is the renewed activity in the railway branches. Wagon works are drawing heavily upon Sheffield's output of steel and springs. Substantial contracts are in hand for wagons for British collieries. Owing to the unsettlement of European exchange rates, less is heard of contracts for railway materials being diverted to Belgium. Agricultural engineers appear to be agreed that the worst has been experienced, and are making small quantities of machine parts for stock in the expectation of a revived demand on home and Colonial account. The biggest expansion of all is in open-hearth steel. The current output for Sheffield and district is greater than in 1914, although, owing to the rapid extension of plant within recent years, a large number of furnaces are still idle. Rolling mills have on hand a substantial tonnage of orders for French engineers. High-speed steel will benefit when low-priced surplus stocks are absorbed. Meanwhile business is mostly confined to inquiries, many of which, however, offer considerable promise. Tool manufacture is steadily being re-established on a firm basis. There is a big business to be done with foreign markets in tools of lower quality than Sheffield usually supplies. Manufacturers have solved the problem of protecting their reputation for first-class articles by using special trade marks for each class of goods. The upward trend of prices in raw and semi-finished materials is gradually gaining strength. Last week's advance of 5*s.* in hematite pig-iron is firmly held. The threatening scarcity in common irons, arising from the increasing consumption in the manufacturing sections, is to be met by the putting into commission of more furnaces in the supplying districts. Large quantities of scrap are required for steel melting. Local supplies are by no means abundant, and a certain amount of British material broken up in Continental yards is going into consumption at Sheffield works.

South Yorkshire Coal Trade.—Though business in house coal is still below the seasonal level, some of the local collieries have more orders than they can execute. The chief drawback is wagon shortage, Operations are being restricted to avoid the accumulation of reserves. Prices for all grades are firmly held. No alteration is anticipated until the new year. Despite loading delays at the docks, South Yorkshire Collieries are doing a heavy business with the Continent. The balance of output is readily absorbed on home contract account. Increased deliveries of cobbles and nuts are being made against the Christmas stoppage. Slacks have benefited from the increased demand for blast-furnace coke. Quotations:—Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 24*s.* to 26*s.*; Derbyshire best house, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best large nuts, 19*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.* 6*d.*; Yorkshire hards, 20*s.* to 21*s.*; Derbyshire hards, 19*s.* to 20*s.* 6*d.*; rough slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; nutty slacks, 7*s.* 6*d.* to 8*s.* 6*d.*; smalls, 3*s.* to 5*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—There is not a great deal doing in Cleveland pig-iron just now, but the feeling of confidence in the near future is rather marked. Values, however, are inclined to ease, due to some qualities being less scarce, and to continued keen competition of other districts. At the same time producers are very loath to acknowledge any actual reductions in quotations, and whilst customers can, in some cases, possibly purchase at slightly less the following are the market rates:—No. 1 and siliceous sort, 95*s.* 6*d.*; No. 3 G.M.B., 91*s.* 6*d.*; No. 4 foundry, 87*s.* 6*d.*; No. 4 forge, 82*s.* 6*d.*; and mottled and white, 81*s.*—all f.o.t. makers' works, or f.o.b. Tees.

Hematite.—There is continued good demand for East Coast hematite, and production is well taken up. Several makers have sold well into next year, but other firms are not quite so favourably placed and are still prepared to grant slight price concessions on the recognised market quotations. The statistical situation generally, however, is very strong, few producers now carrying stocks of any moment. Nos. 1, 2 and 3 are put at 93*s.* 6*d.* and No. 1 at 94*s.* 6*d.*, and though possibly orders can be placed at less these figures have been paid both for early and forward delivery.

Foreign Ore.—Extreme quietness characterises foreign ore, consumers still holding off the market, but there are sellers who will not entertain offers at the low figures mentioned. Best rubio is quoted 21*s.* 6*d.* to 22*s.* 6*d.* c.i.f. Tees, and several sellers are asking up to 23*s.* for delivery over periods next year.

Blast-Furnace Coke.—Durham blast-furnace coke is in fairly good demand, but local users are very disinclined to pay any more than 29*s.* for average qualities delivered,

at round about which figure they declare they can satisfy needs.

Manufactured Iron and Steel.—Better accounts are given of several branches of finished iron and steel. Inquiries are quite good and orders for rails, constructional material, and railway requisites have been secured. Among the principal market quotations are :—Common iron bars, 10*l.* 10*s.* ; iron rivets, 11*l.* ; packing (parallel), 8*l.* ; packing (tapered), 11*l.* ; steel billets (soft), 8*l.* ; steel billets (medium), 8*l.* 10*s.* ; steel billets (hard), 8*l.* 15*s.* ; steel boiler plates, 12*l.* 10*s.* ; steel ship, bridge and tank plates, 9*l.* to 9*l.* 5*s.* ; steel angles, 8*l.* 15*s.* ; heavy sections of steel rails, 8*l.* to 9*l.* ; fish plates, 13*l.* to 14*l.* ; black sheets, 11*l.* 10*s.* ; and galvanised corrugated sheets, 17*l.* 10*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Conditions in the Scottish steel trade have not yet got much beyond the state of hopefulness, but there is nevertheless a much brighter outlook all round. Consumers of steel material have been slowly picking up orders of one sort and another, and it cannot be long before the demands made on steel makers show a decided increase. The outlook on the Clyde has improved by the placing of several new contracts and there are prospects of quite a number of others being fixed up before long, but the exclusion of the Clyde from the new Admiralty programme has come as rather a severe blow to this district. The securing of the order for at least one battleship would have made for considerable activity in different directions. The current demand for steel is still somewhat limited, and ship plates, sections and even boiler plates, which were recently reduced in price, are very slow of sale. Inquiries continue to be better and therein lies one of the sources of the improvement in the outlook, but the export trade is rather poor still. The position in the black steel sheet trade has not improved much, if any, and business is largely composed of export orders for the thin gauges. Prices are unchanged, but exhibit a firmness all round. The following are to-day's quotations :—Boiler plates, 12*l.* per ton ; ship plates, 8*l.* 15*s.* per ton ; sections, 8*l.* 7*s.* 6*d.* per ton ; and sheets, 10*l.* 10*s.* per ton, all delivered, Glasgow stations.

Malleable Iron Trade.—One week is very like its predecessor just now in the malleable iron trade of the West of Scotland, and there is little disposition on the part of buyers to commit themselves at present. A few forward contracts have been fixed up, thus ensuring a certain amount of work after the approaching year-end holiday stoppage. The current output is of a restricted nature, but in the re-rolled steel departments there is a certain amount of activity going on. Prices are firm with "crown" bars called 10*l.* 10*s.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—There has been little change in the Scottish pig-iron trade position this week and little fresh business of any importance has been booked. Local buying is very slow, but the outlook is again showing brighter prospects. Hematite iron is the subject of more inquiry, but foundry grades are in less request, and some Continental competition is being felt at present. The export outlook is not too promising at the moment, as the American business has dwindled down to very small proportions, but a few new inquiries have come to hand from that quarter and some dealing may result. A hopeful sign is that one or two other foreign markets have been sending out feelers of late, and business is probable. Prices are without change, and are as follow :—Scottish hematite, 5*l.* 7*s.* 6*d.* per ton, delivered at the steel works ; foundry iron, No. 1, 5*l.* per ton, and No. 3, 4*l.* 15*s.* per ton, both on trucks at makers' works.

Scottish Pig-Iron Shipments.—The amount of pig-iron shipped from Glasgow Harbour for the week ending last Saturday, December 9, was 1,624 tons foreign and 140 tons coastwise. This compares with the totals for the corresponding week of last year, when the figures were 75 tons foreign and 86 tons coastwise, a total of 161 tons.

Shipbuilding.—Keen disappointment is very general to-day all over the West of Scotland because the Clyde has been passed over in the new order for battleships. The matter of price had much to do with it, and a London authority states that the lowest Clyde offer only ranked fourth on the list. Other work is being secured slowly but surely by shipbuilders, and several new contracts have lately been fixed up. Among those reported are the following : Messrs. Napier and Miller, Limited, Old Kilpatrick, are to build two out of ten cargo steamers ordered by the new Canadian Steamship Company. These steamers will have a deadweight carrying capacity of 2,500 tons. The same firm have secured an order from the Court Line, Limited, London, for a steamer of 8,000 tons deadweight cargo-carrying capacity. These orders are very welcome as the firm has little work on hand at the moment. Messrs. Fleming and Ferguson, Paisley, have secured the contract to build a large modern type of dredger for the Tyne Improvements Commissioners. Messrs. Ramage and Ferguson, Leith, have received an order for an 800-ton yacht for an Egyptian Prince. She will have twin screws and Diesel engines, and will be the most powerful ship of its kind afloat.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Exports of coal as cargo from South Wales in November amounted to 2,349,180 tons, compared with 2,405,917 tons in October and 2,524,718 tons in September. Shipments to France, Spain, Portugal, Greece, British coaling depots, and "other countries" were increased in November, but to South America, the United States and Canada, and also Italy they showed a reduction. Those to the States receded from 114,920 tons in October to 43,810 tons in November, and to Canada from 73,373 tons to 35,800 tons; but to France they were increased from 792,978 tons to 871,242 tons, to Spain from 112,158 tons to 137,377 tons, to British coaling depots from 197,927 tons to 226,066 tons, and to "other countries" from 336,447 tons to 381,158 tons. Those to Italy dropped from 400,434 tons to 305,335 tons, and to South America from 304,158 tons to 237,600 tons. Thus while trade with the temporary markets of the States and Canada has considerably depreciated, with the normal markets there has been a general improvement, and but for delays in shipment operations at the docks it is believed that the November returns would have shown an increase. The railway company and the employers, however, are taking active steps to induce the coal trimmers and tippers to introduce a third shift with a view to speeding up exports and minimising delays. Meanwhile new business on the coal market is curtailed by the scarcity of free supplies, and prices consequently are fully maintained on the basis of 29*s.* for best Admiralty large and 18*s.* 6*d.* for best steam smalls. Inquiries are circulating for fairly substantial quantities over next year, and negotiations are proceeding. The Central Argentine Railways have booked up over 200,000 tons of second Admiralty large and best Monmouthshires over next year on the basis of 26*s.* for the former and 25*s.* to 25*s.* 6*d.* for the latter, while the Peninsular and Oriental Steam Navigation are also stated to have contracted for 100,000 tons of best Admiralty large.

Iron and Steel Trades.—Shipments of iron and steel from South Wales last week amounted to 20,590 tons compared with 13,722 tons in the previous week. Of the total, 14,940 tons consisted of tinplates compared with 5,261 tons ; 1,669 tons blackplates against 2,299 tons ; 1,566 tons galvanised sheets against 788 tons ; and 2,415 tons of other iron and steel goods against 5,374 tons. The sudden advance in the minimum price of Welsh tinplates to 20*s.* per box has restricted business, having upset the calculations of merchants who had speculated rather freely on the old minimum basis of 19*s.* and 19*s.* 3*d.* The decision to increase the price of tinplate bars by 3*s.* 9*d.* per ton at the close of the year also had a restrictive influence.

Dock Charges Reduced.—The Great Western Railway Company, owners of the South Wales docks, have decided to reduce tonnage rates on vessels from 100 per cent. to 75 per cent. above the corresponding charges in operation in December, 1913, and tipping and weighing charges from 9*d.* per ton to 8*d.* per ton, provided that the average weekly traffic in the three months ending December approximates in volume the average for the first two weeks in October. The provisional reductions are to come into operation on January 1 next. In the week ending October 7 foreign coal exports amounted to 543,678 tons, and in the following week to 533,842 tons ; in the subsequent eight weeks the average was 560,000 tons, or 20,000 tons to 30,000 tons above that required to make the reductions operative.

Westville Steamers Sold.—The three steamers Avanville, Polly Bridge and Shorcham, which cost the Westville Shipping Co., Limited, Cardiff (in liquidation), £148,400, have been sold by the bank, who were mortgagees, to James Henry Monks (Preston), Limited, of Liverpool, for £35,000, or £14 19*s.* per deadweight ton.

THE LATE MR. B. S. BROADHURST.—We regret to have to report the death, which occurred on Monday, the 11th inst., of Mr. B. S. Broadhurst, managing director of the Brush Electrical Engineering Company, Limited. Mr. Broadhurst's activity in the service of that company extended over a period of about forty years. He had won the esteem of all who came in contact with him, and will be missed by a large number of friends.

HOTEL EQUIPMENT EXHIBITION AT MILAN SPRING FAIR.—The Department of Overseas Trade is informed by H.M. Consul-General at Milan that the Touring Club Italiano, of Milan, intends to hold a special exhibition of articles of hotel equipment in conjunction with the annual international Samples Fair at Milan, to be held from April 12 to 27 next year. H.M. Consul-General considers that the proposed exhibition offers a good opportunity for high-class firms to demonstrate the general excellence of British hotel equipment.

JIG AND TOOL DESIGN.—Many draughtsmen in motor engineering firms will be interested in the existence of a class for instruction in jig and tool design, at the Polytechnic, 309, Regent-street, W. 1. The class is conducted by Mr. C. A. Clarke, who acts as instructor, and is held on Mondays from 7.30 to 9.30. The next term will begin on January 8. The fee for students residing in the Administrative County of London or the County of Middlesex is 10*s.* for the term ending April, 1923. For students residing in counties other than London and Middlesex, but working inside London, the fee is 1*l.*, or for such students working outside the Administrative County of London the fee is 2*l.*

SUPPORT IN IRON ORE MINES.—Particular attention is being given at the Southern experiment station of the United States Bureau of Mines at Birmingham-Tuscaloosa, Alabama, to a study of support in iron ore mines, and preliminary tests have been completed on some 35 cubes of ore prepared for crushing tests. The object of the preliminary work was to determine the size of test cubes most suitable for obtaining the ultimate strength of the ore, and to secure some definite information regarding failure of ore under crushing loads. In general it may be said that the ore will sustain loads up to 10,000 lb. per square inch, beyond which it is not safe to go in the dependence of the ore as a means of support.

NOTICES OF MEETINGS.

THE INSTITUTION OF PRODUCTION ENGINEERS.—Friday, December 15, at 7.30 p.m., at the Engineers' Club, Coventry-street, W. 1. "The Production Engineer," by Mr. H. E. Honer.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Friday, December 15, at 6.30 p.m., at the Engineers' Club, Coventry-street, W.1. Paper by Mr. O. T. Gnosspelius, A.C.G.I., A.F.R.Ae.S., on "Experimental Data without Wind Channel."

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 15, at 6 p.m., "Reclamation Plant and Its Operation," by Mr. Gascoigne Lumley, I.S.O., Member.

THE INSTITUTION OF CIVIL ENGINEERS : YORKSHIRE ASSOCIATION.—Friday, December 15, in the Philosophical Hall, Leeds. Paper by Mr. G. B. Jones, on "Corrosion."

THE JUNIOR INSTITUTION OF ENGINEERS : NORTH-EASTERN SECTION.—Saturday, December 16. A Visit will be made to the Central Telephone Exchange, Newcastle-on-Tyne.

THE INSTITUTION OF RUBBER INDUSTRY : MANCHESTER SECTION.—Monday, December 18, at 7.30 p.m., in the Banqueting Hall, Midland Hotel, Manchester. Paper by Mr. Fordyce Jones, on "A Bigger and Better Rubber Sundries Trade."

THE BRADFORD ENGINEERING SOCIETY.—Monday, December 18, at 7.30 p.m., in the Hall of the Bradford Technical College. Lecture by Mr. O. C. Dinerman on "Electric Control Gear," illustrated by lantern slides.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 19, at 6 p.m. Paper to be submitted for discussion : "Extensions at Tilbury Docks, 1912–1917," by Mr. Francis Maurice Gustavus Du-Plat-Taylor, M.Inst.C.E. Students' Visit, Saturday afternoon, December 16, to the Greenwich Power Station of the London County Council Tramways.

THE INSTITUTION OF AUTOMOBILE ENGINEERS : NORTH OF ENGLAND CENTRE.—Wednesday, December 20, at 7.30 p.m., at the Royal Technical College, Peel Park, Salford. "The Duty of High Tension Ignition Apparatus," by Mr. J. D. Morgan.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, December 20, at 5 p.m., at 49, Cromwell-road, South Kensington. The following papers will be read : (1) "The Study of Radiotelegraphic Atmospherics in Relation to Meteorology," by Mr. C. J. P. Cave, M.A., and Mr. R. A. Watson Watt, B.Sc., F.Inst.P. ; (2) "Winter Thunderstorms in the British Islands," by Mr. C. J. P. Cave, M.A. ; (3) "Forecasting Sky Types," by Mr. D. E. Row.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, December 21, at 5.30 p.m., at the Rooms of the Geological Society, Burlington House, Piccadilly, W. 1. Discussion on "Notes on the Correction required to Aneroid Readings for Altitude to Counteract the Effect produced by the Diurnal Barometric Wave," by Franklin White ; "Some Notes on the Secondary Sulphide Enrichment Exhibited by Certain Auriferous Veins," by Mr. P. C. Whitehead.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, December 22, at 7.30 p.m., at 39, Victoria-street. Social evening.

THREE BRAKE HORSE-POWER HOPPER-TYPE PARAFFIN ENGINE : ERRATUM.—In our account of Messrs. Drummond Brothers' new paraffin engine, which appeared on page 707 of our last issue, the capacity of the pump which is built for use with the engine was given as 1,000 gallons per minute instead of 1,000 gallons per hour.

CONTRACTS.—The Mendip Granite and Asphalte Company, Limited, have decided to put down additional plant, in order to cope with the increasing demand for road material. The contract for the whole work has been entrusted to Messrs. Vickers, Limited, who will supply and erect the stone breakers, elevator, screens, together with the steel storage bins and power installation

INDIANA OIL SHALES.—Experimental work on the Indiana oil shales, performed in co-operation by the Department of Geology, Indiana University, and the United States Bureau of Mines, indicates that in most places about 100 ft. of this shale is available, that the upper 35 ft. is the richest, yielding between 12 gallons and 14 gallons per ton, that the middle section is very lean, and the lower section richer, although not as rich as the upper part. In most places the shale contains a comparatively large amount of motor fuel of relatively good quality.

INTERNATIONAL FOUNDRY TRADES EXHIBITION.—Arrangements have now been made by the Birmingham Chamber of Commerce, in conjunction with the British Cast-Iron Research Association, to hold the next International Foundry Trades Exhibition at Birmingham in the early summer of 1924, and every effort will be made to make it as comprehensive as possible. The exhibition of 1922 was the first of its kind in this country and was a great success. Steps will be taken to ensure a greater international representation at the 1924 Exhibition and to increase the schedule of the foundry employees' competitions, which were so very successful. The Chamber of Commerce is to be congratulated upon their early decision to bring together a further exhibition to improve the cast-iron foundry industry.

ROTARY AIR COMPRESSORS.

CONSTRUCTED BY THE SWISS LOCOMOTIVE AND MACHINE WORKS, ENGINEERS, WINTERTHUR, SWITZERLAND.

(*For Description, see Page* 740.)

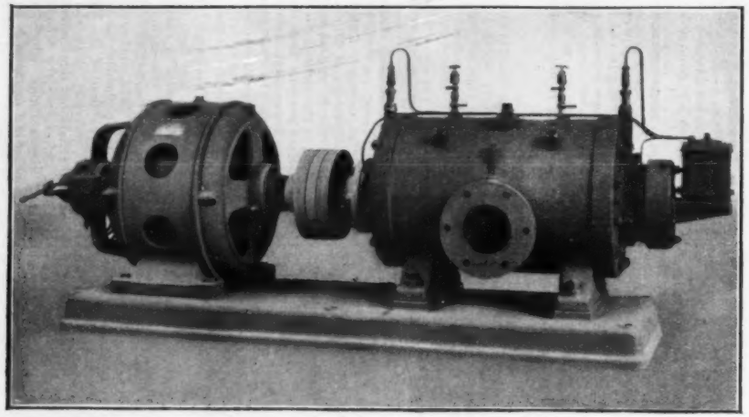


FIG. 12. SINGLE-STAGE COMPRESSOR WITH MOTOR DRIVE.

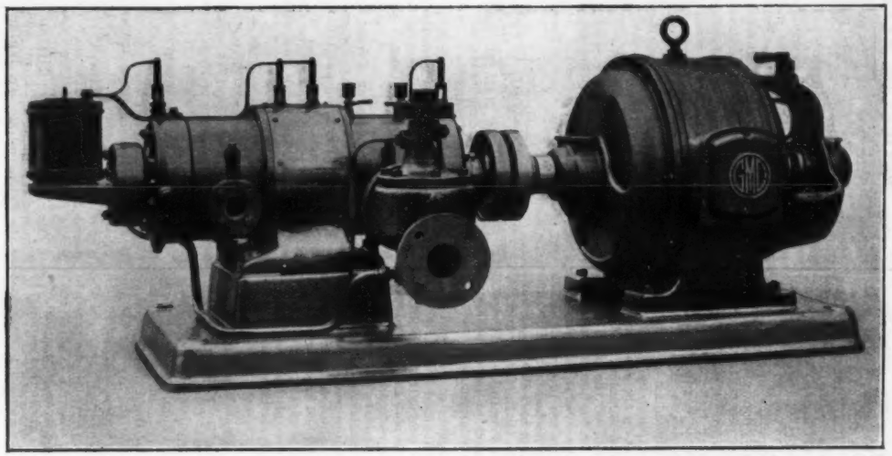


FIG. 13. TWO-STAGE COMPRESSOR WITH MOTOR DRIVE.

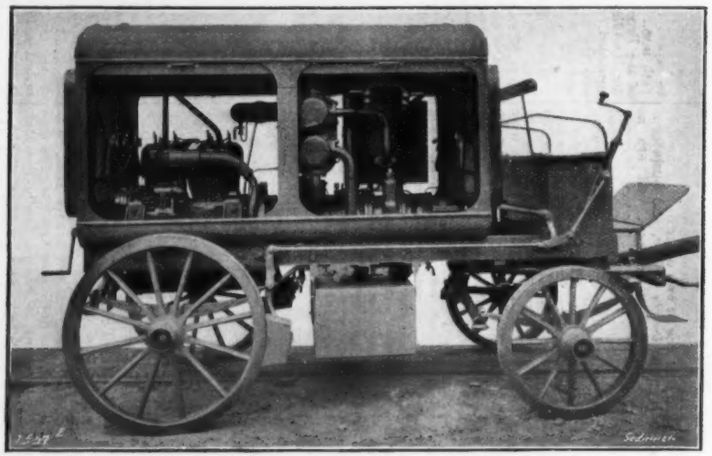


FIG. 14. PETROL ENGINE-DRIVEN COMPRESSOR MOUNTED ON A HORSE VEHICLE.

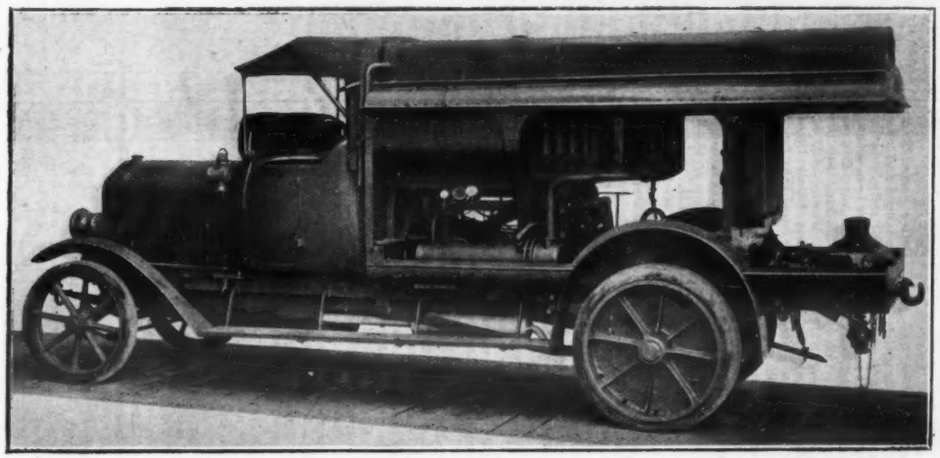


FIG. 15. PETROL ENGINE-DRIVEN COMPRESSOR MOUNTED ON MOTOR LORRY.

THE FULLY HYDRO-ELECTRIC POWER STATION, S

(For Description, see Page 7

Fig. 76.

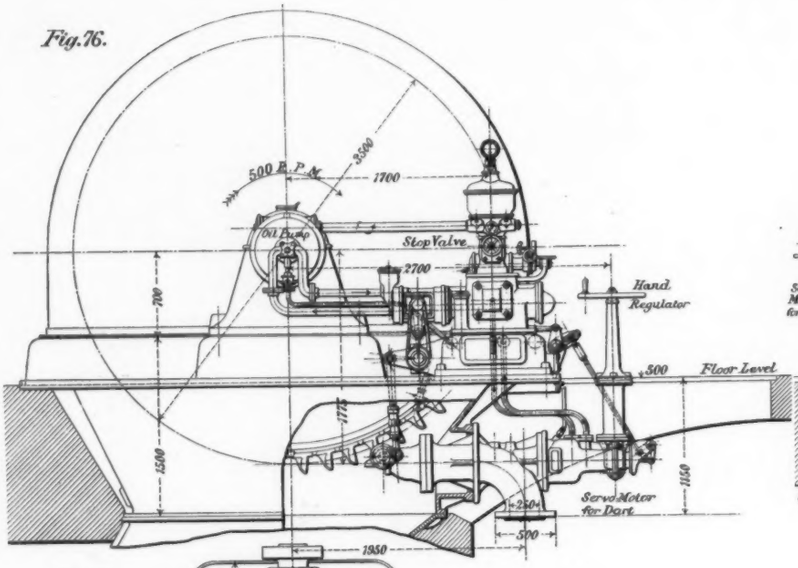
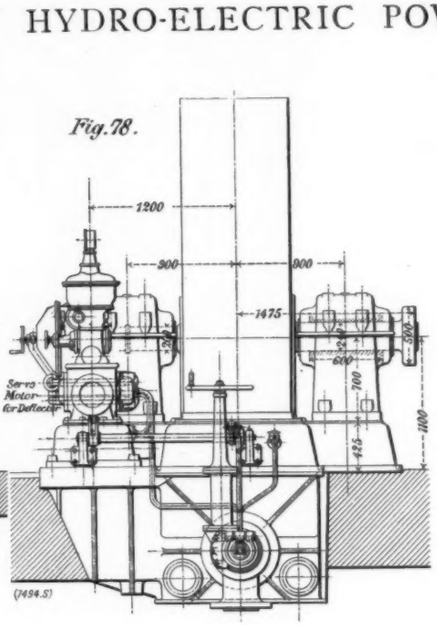


Fig. 78.



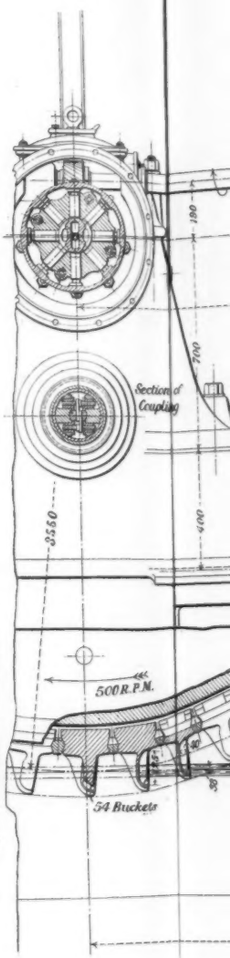


Fig. 77.

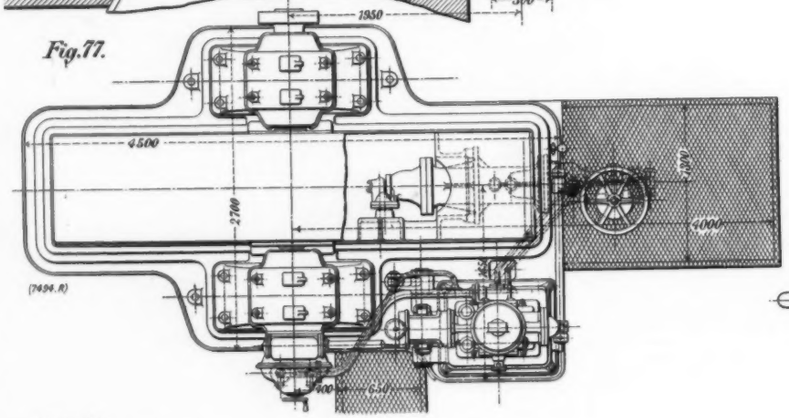


Fig. 81.

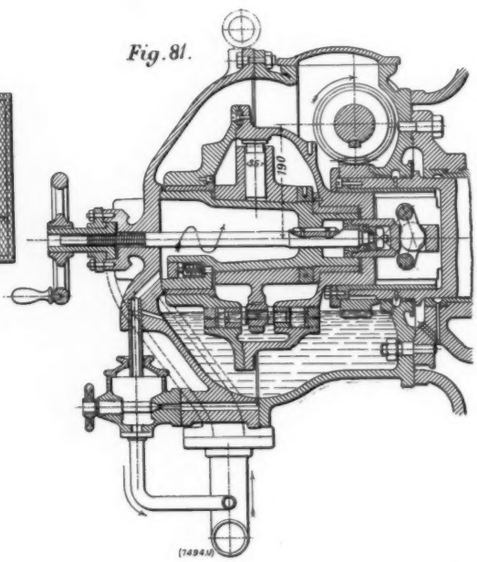


Fig. 82.

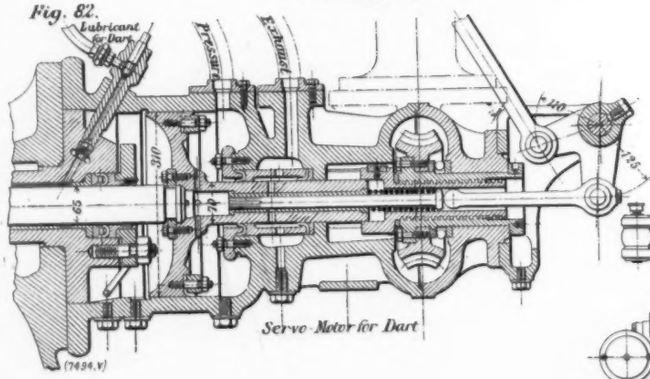


Fig. 84.

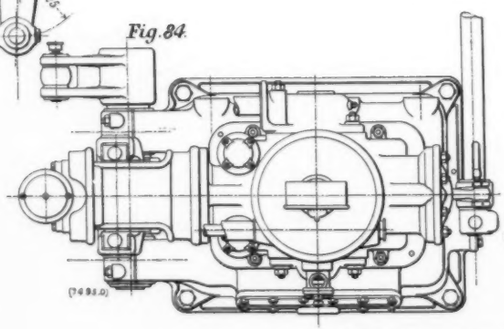


Fig. 85.

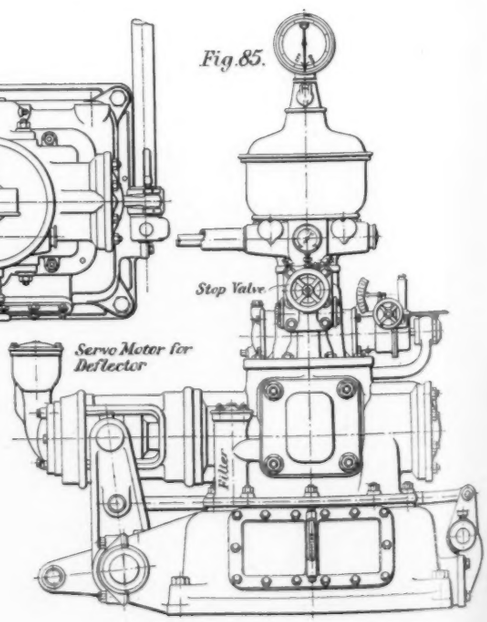
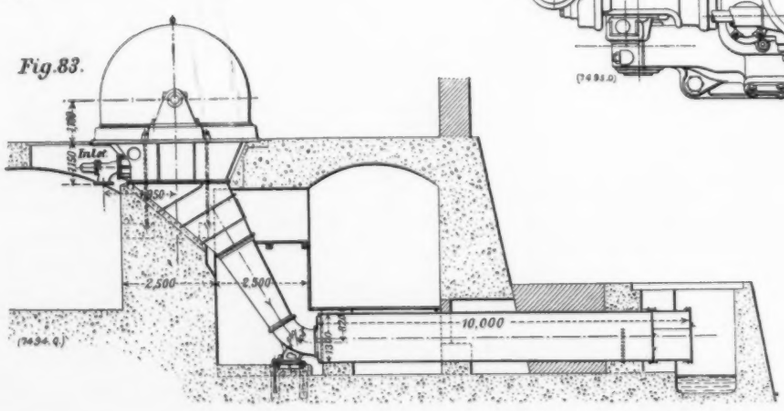


Fig. 83.



ATION, SWITZERLAND: DETAILS OF TURBINES.

(cription see Page 731.)

Fig. 79.

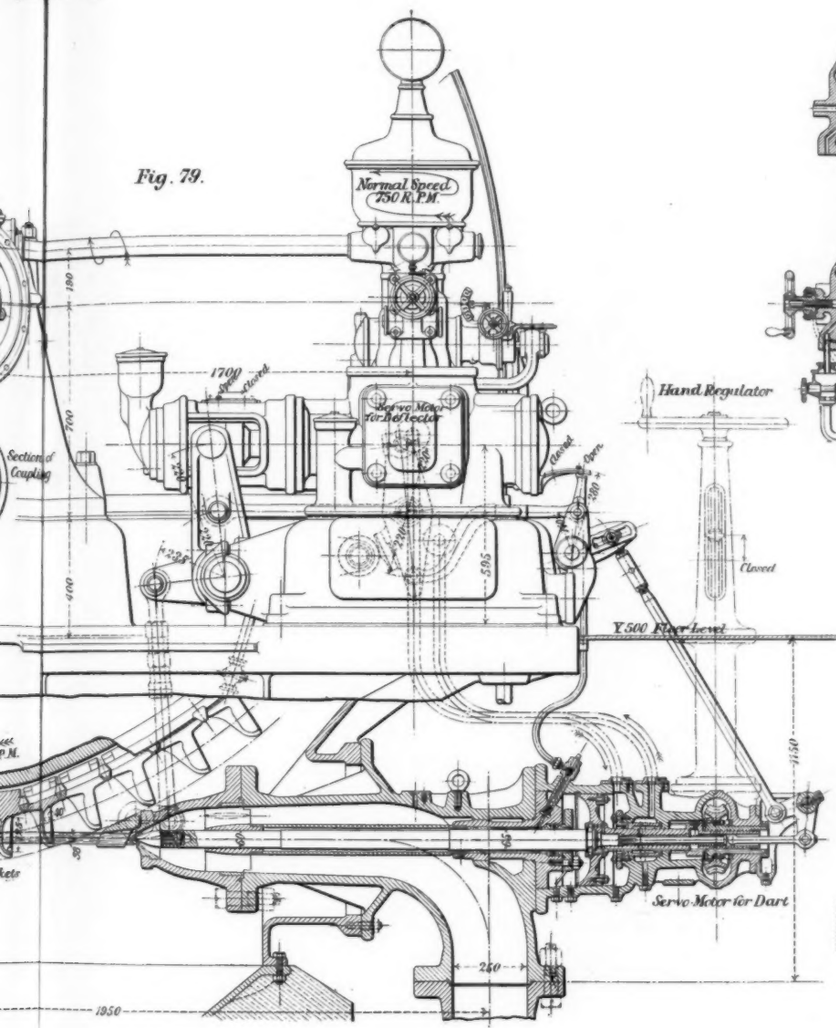


Fig. 80.

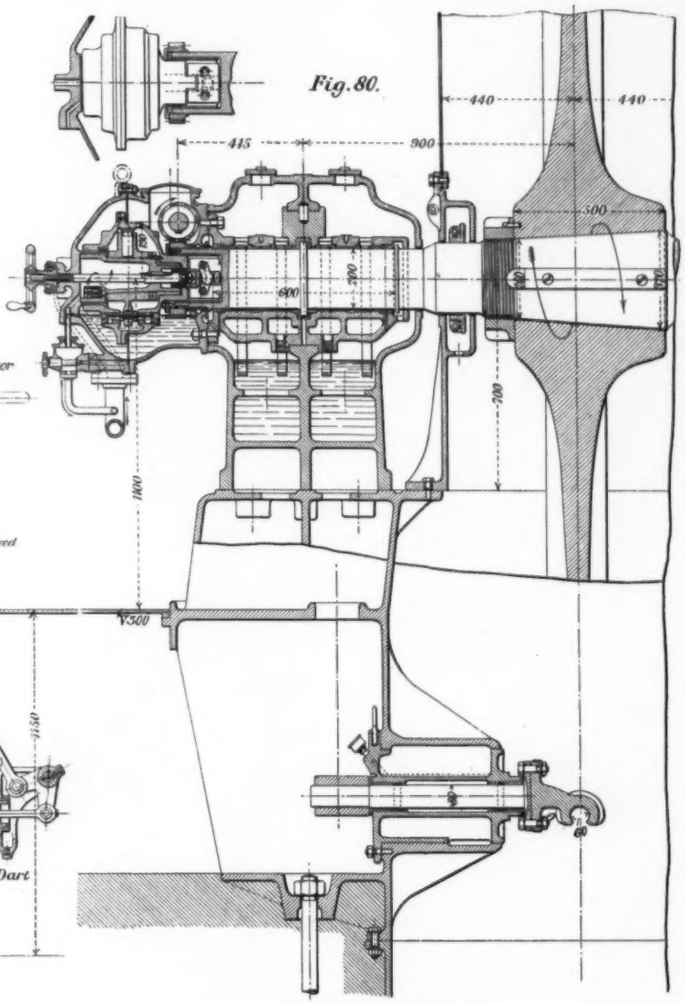


Fig. 86.

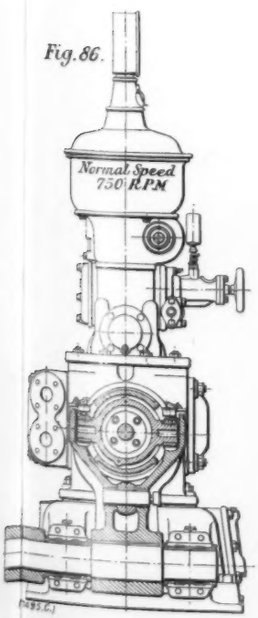
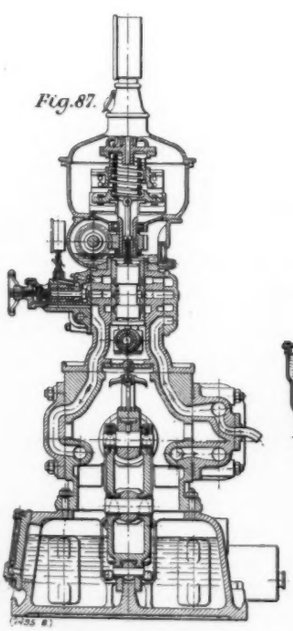


Fig. 87.



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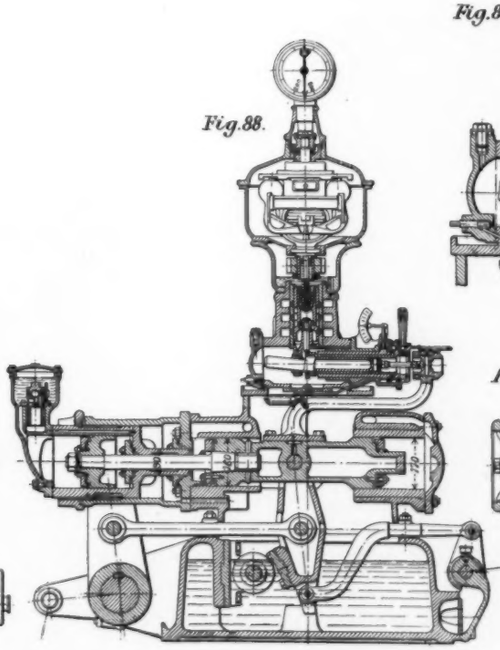

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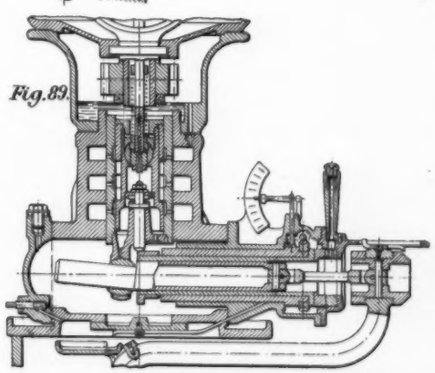

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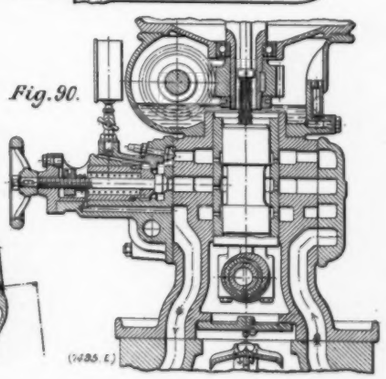

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CONTENTS.

	PAGE
The Determination of the Calorific Value of Liquid Fuels (*Illus.*)	729
The Fully Hydro-Electric Power Station, Switzerland (*Illus.*)	731
The Cycle and Motor-Cycle Show (*Illus.*)	734
The Abramsen Straightening Machine for Round Bars and Tubes (*Illus.*)	736
Physical Society of London	738
Letters to the Editor.—"Double-Reduction Gears for Turbines" (*Illus.*), "The Theory of the Airscrew" (*Illus.*)	738
Rotary Air Compressors (*Illus.*)	740
The Atomic Process in Magnetisation	742
Notes from South Yorkshire	742
Notes from Cleveland and the Northern Counties	742
Notes from the North	743
Notes from the South-West	743
Notices of Meetings	743
Theory and Practice	745
The Patent Position	746
The Panama Canal	746
Corrosion Problems	747
Road Construction (*Illus.*)	748
Notes	749
Industrial Notes	750
The Late Colonel John M. Denny (*With Portrait*)	751
The International Electrotechnical Commission	751
New Power Station at Leicester	752
The Institution of Locomotive Engineers—Presidential Address (*Illus.*)	753
Factory Planning (*Illus.*)	756

Two-Page Plate.—THE FULLY HYDRO-ELECTRIC POWER STATION, SWITZERLAND: DETAILS OF TURBINES.

ENGINEERING.

FRIDAY, DECEMBER 15, 1922.

THEORY AND PRACTICE.

THE alleged antagonism between theory and practice has for many generations been a stock subject for comment. Our ancestors had the proverb that an ounce of practice was worth a pound of theory, a conclusion which may have been true enough in the early stages of our knowledge of natural phenomena. Newton's "*hypotheses non fingo*" sounds curious in view of the circumstance that he was responsible for the theory of universal gravitation and for the corpuscular theory of light, both of which have proved of immense service in their day and time, and indeed, there is a tendency to revive in a modified form, the second of these hypotheses in order to account for photo-electric effects, and for most practical purposes the gravitational theory will probably permanently survive. No doubt the phrase in question must be construed in the main as a protest against the mediæval school of natural philosophers, who displayed a truly feminine fertility in framing ingenious theories and in adhering to them in spite of conflicting facts. One of Galileo's contemporaries, it will be remembered, refused to look at Jupiter's satellites through the newly-invented telescope for fear lest the result should be a disturbance of his settled conviction of a geocentric earth. It was this proneness to theorise and to ignore observation which led Bacon to the opposite extreme and caused him to propose what subsequent experience has proved a very infertile method of scientific inquiry.

To-day we frame theories, but we test them thoroughly, a policy for which the mediæval philosopher in general lacked the means, even had he the inclination. The result has in many directions revolutionised not only our views as to the constitution of Nature but also as to the significance of a scientific theory itself. Fifty years ago the idea was prevalent that absolute truth had either been attained or was attainable, but now, as Sir J. J. Thomson has so well expressed it, a scientific theory is regarded as a policy rather than a creed.

Even doctrines formerly regarded as fundamental are now challenged. Thus the constancy of mass in chemical combinations is no longer regarded as an ultimate verity, but merely as true within the limits of accuracy of our experiments, and whilst no engineer would cross the street, or even the room, to view a machine which professed to violate the doctrine of conservation of energy or the conservation of momentum, there are strong psychological reasons for believing that whilst true for the macrocosm, neither law necessarily holds in all cases for the microcosm.

In this connection it is interesting to note how cautious Lord Kelvin was in framing his statement of the second law of thermodynamics, a caution which received the commendation of Helmholz. So long as "mind" does not intervene, the second law holds, but Clerk Maxwell's demons would have no difficulty in constructing and operating a perpetual motion machine. The living leaves of a tree prevent or retard the degradation and increase of entropy of the solar energy they intercept, and it is difficult to believe that this is effected without some form of guidance by which the flow of energy is diverted from its natural path, just as, to use a somewhat rough analogy, a signalman diverts a heavy goods train by shifting the points. In this latter case, the change of momentum, directly attributable to the signalman, may be made almost indefinitely small in comparison with the total change effected when a train is diverted from the main line to a branch, but though almost indefinitely small it is never actually zero, and the evidence for these two great generalisations is valid only up to the limits fixed by our means of measurement.

These are yearly becoming more refined, and we believe that, although there is evidence that the law of force inside of an atomic nucleus differs from the ordinary, momentum is nevertheless conserved when a radioactive atom explodes and emits an α particle. No measurement can, however, prove that any rule holds indefinitely beyond the limits covered by the actual observations. Any conclusions as to what occurs in the ultimate cannot therefore be no more than inferences, and may consequently be modified by inferences derived from other fields of investigation.

In his presidential address to the Junior Institution of Engineers last Tuesday, Captain Riall Sankey discussed "The Utility of Theory to the Practical Man." No doubt were new departures never made, experience would prove almost all-sufficing, but the world moves and novel problems cannot be economically solved without theoretical guidance. Captain Sankey illustrated this very effectively by a comparison of different categories of bridge work. Thus, a line of wheeling planks and its supporting "horses" is in essentials a bridge of many spans, but no one would think of fixing its proportions by computation. The ganger knows from experience and tradition exactly what is required. Coming to a rather more complicated case the proportions of the temporary structures used for railway deviations are often fixed entirely by rule of thumb and with complete success, ample experience in such work having been obtained in the past, though it is highly probable that when work of this class was first attempted the engineer responsible gave much anxious thought and made many rough calculations as to the scantlings required. The "practical man" unversed in theory who often carries out work of this kind with rapidity, economy and success, would, however, be the first to admit his incompetence to design a Forth Bridge. In short, if the practical man is to be permanently engaged on a definite and unchanging class of work his theoretical requirements may be small, but it must at the same time be admitted that no class of society is fonder of forming theories than is the purely shop-trained man. This defect often shows itself in a very aggravating fashion when the ordinary clever mechanic is sent to report upon some accident of a type of which he has had no previous experience. Such a man is very prone to invent some hypothesis as to what has actually occurred and colours his statements accordingly, observations which conflict with his theoretical views being completely ignored.

The history of the past thirty years affords pretty conclusive evidence as to the value of theory to the mechanical engineer. By a slow and expensive process of trial and error, extending over more than a century, engineers had succeeded in constructing

good steam engines, unassisted by theoretical considerations save of the most general character. Fortunately, however, the innate curiosity of mankind led to the formation of a science of thermodynamics, which turned out to be very directly applicable to the steam turbine, and the extraordinarily rapid improvement and development of this form of prime mover is undoubtedly largely attributable to the circumstance that a reasonably adequate theory was immediately to hand. The same observation applies to the rapid progress of heavy electrical engineering; and these two events constitute an irrefutable reply to those, we have still amongst us, who contend of theory, as Sir Percy Scott's midshipman does of the battleship, that "it is no d——d use."

Captain Sankey's address was directed to showing the utility of theory to the practical man, but, of course, the main incentive to the pursuit of science is not its immediate or even its ultimate utility to the race, using the word utility in its restricted and no doubt illegitimate materialistic signification. Man's appetites and desires are not wholly material, and what satisfies any of them must in the ultimate have a utilitarian value. The main impulse to inquiry, either in pure or applied science, is the satisfaction our innate curiosity as to the inner nature of the cosmos. In some cases, as in that of the marvellous astronomical measurements recently made by Michelson in America, by which the diameter of Betelgeuse was determined, the result may never find any practical application, but in others, as for example, in the apparently equally useless (from the contemporary standpoint) experiments of Dr. Gilbert on electricity and magnetism, the ultimate outcome may be the foundation of great industries. The one research is, however, fully as legitimate as the other, and in fact "applied research" seldom results in more than reforms. Investigations which ultimately prove of primary importance have in general been conducted with no immediate practical application in view. Unfortunately, no doubt, results thus obtained are seldom immediately useful. Much effort must be expended in experiment and heavy expenses have to be incurred before the new theory becomes embodied in practically useful plant, and it is not always the immediate formulator of the theory who proves most successful in this work of practicalisation. A notable instance of this was brought forward by Captain Sankey, who stated that the original Diesel engine proved an utter and complete failure. So far from generating motive power it had to be motored round, and final success was only attained by alterations carried through in the face of Dr. Diesel's opposition, the cycle of operations being completely modified in the process. This state of affairs is, however, rather the exception than the rule. Generally great inventors find it necessary, as did Sir Henry Bessemer, to practicalise their ideas themselves, as the "practical man" is readily disheartened by the partial failures and contretemps inevitably associated with pioneering work.

THE PATENT POSITION.

The regularity with which patent applications are filed under normal trade conditions and the fluctuation as the industrial position changes being well known, it is interesting from time to time to follow the patent position. At present, patent applications are being filed in this country at a rate exceeding the rate of the corresponding period in any year back to 1913, with the exception of 1920, the year in which there was an enormous influx of foreign patent applications under the Peace Treaty. Applications lodged during the first ten months of the year during recent years number approximately as follows:—

1913	24,800
1914	22,000
1915	15,500
1916	15,600
1917	16,200
1918	17,800
1919	27,100
1920	30,800
1921	29,000
1922	29,500

Applications have been lodged at a fairly uniform rate throughout the various years, with the exception of the autumn of 1914, the beginning of the war, the winter of 1918 following the armistice, and the summer of 1920, the inauguration of applications under the Peace Treaty with Germany. It therefore seems clear that British manufacturers as well as foreign applicants are more and more coming to the opinion that British patents have a definite value to them in industry. It is very difficult to ascertain what is the corresponding position as regards applications filed in foreign countries on behalf of British firms. The general position seems to be that applications are filed in those countries in which firms have a direct interest, rather losing sight of the fact that as conditions change it may well be worth while for a firm to own patents in other countries, but they may come to that conclusion too late if publication has been made even in this country. The laws of foreign countries differ very materially, but in only a few can valid patents be secured if publication has taken place in the foreign country, and such a publication commonly results from the printing of a British specification. British patents are circulated to most foreign States.

In order to deal with a position of this kind and also to reduce the cost to patentees, suggestions have been made from time to time that there should be provided means for obtaining either world-wide protection, protection under all the States parties to the International Convention for Industrial Property, or at least a patent covering all territories within the British Empire. Even yet something might be done on these lines, but it is likely to take a considerable period before anything practical can be devised. Such facts that some countries make a search in respect of novelty of the application and that others do not, although this may seem a small point, would need very careful handling if a patent were to be granted for the protection of an invention in both types of countries.

Foreign laws have been changing with considerable rapidity during the last few years, and this again would make any patent covering an extended ground difficult to materialise. Quite recently new laws have been passed in Finland, Latvia, New Zealand, Sarawak, Rhodesia and Japan, the latter especially containing important new provisions. All these will need to be investigated by those inventors who have inventions likely to be of use or to be capable of manufacture in such territories.

There is just one other point that should be mentioned in connection with patents at the present time, that is, that those investigating whether they can manufacture notwithstanding patents that may be in existence should recollect that if the patents have been restored under the Peace Treaties, the grants are restricted, and those patents therefore do not cover persons excepted by the Peace Treaty as being in possession of the invention. Doubtless in due course the High Court of Justice will interpret the scope of such grants, but in the meantime it is well that those interested should remember that there is a definite point for consideration in this matter.

THE PANAMA CANAL.

With the experience of several years of use the operation of the Panama Canal would appear to be improving. Up till the end of the year concluding with June 30, 1922, the canal had been used by over 61 million tons of shipping, vessels of the United States and United Kingdom representing by far the greater portion of the whole. Of these two countries the latter had the better start, but though the original figure has been considerably raised, the use now made of the Canal by the United States greatly exceeds that by British shipping. Both countries have fluctuated, but since the war United States shipping has risen to and exceeded 5 million tons in a year, while the highest British tonnage registered was in 1920–21 when 3,738,257 tons used the Canal. Last year this amount had decreased to 3,329,861 tons. The only two other notable contributions by individual nations are those by Norway and by Japan. Over the years the Canal has been opened the use made of it by the former has varied greatly. Tonnage of that country to the amount of over 1 million made use of the waterway in 1918, but it has never since reached this mark, and last year little more than 400,000 tons of Norwegian shipping passed through it. The case of Japan is more interesting for it is the one country showing progressively increasing use of the Canal. Commencing with 42,000 tons in 1915, without a single setback this amount has yearly increased until this last year, for the first time, it surpassed the 1 million mark. The total for all countries last year was 10,884,910 tons, or less than in the previous year by about 700,000 tons.

The final report for the year of the working of the Canal gives some interesting figures regarding origin and destination of the traffic using the Canal. From these it is clear how much of the United States traffic is of a coastal nature. Of the traffic passing from the Atlantic to the Pacific, for instance, 68·6 per cent. of the total originates on the East Coast of the United States, and 30·5 per cent. of the total is destined for the West Coast of that country. In the reverse sense, from the Pacific to the Atlantic 53·2 per cent. of the total originates on the West Coast of the United States, and 42·7 per cent. of the whole is destined for the East Coast. In fact, the purely coast-to-coast traffic of the United States accounts for over one-quarter of the whole amount.

It is rather interesting to note that whereas tonnage from the British Isles passed from the Atlantic to the Pacific to the amount of 642,792 tons only, in the reverse direction no less than 1,676,586 tons were destined for the British Isles, and the tonnage destined for other European countries totalled over 1 million in the year. On the whole the balance of traffic is, however, from the Atlantic to the Pacific, but the excess of the one over the other is only about 100,000 tons in traffic amounting to approximately 5½ million tons each way.

With accumulated experience various improvements have been made in working vessels through the Canal. This operation is only performed in daylight at present, but any vessel arriving at the terminals before 1.30 p.m. can pass through the Canal the same day. The working is arranged on a prearranged time schedule which ensures that vessels shall arrive at the locks when there are no adverse currents set up by lock operations. As yet operation by night is not justified. The total number of lockages in the twelve months was 8,834.

A good deal has been heard during the year of a possible shortage of water supply for the canal for the purpose of locking vessels through, if the traffic should increase considerably. It has, however, been definitely reported that with further possible storage schemes it will be feasible to ensure a sufficiency of water to meet the maximum possible requirements of the Canal, *i.e.*, provision for the continuous locking through of vessels at the greatest workable rate. It will be many years before this situation arises. While the fact is reassuring it seems clear that the effect of seasons of low rainfall since the opening of the Canal has not been quite what was anticipated when the scheme was in process of realisation. The margin appears to be ample for a long while into the future, but it has wisely been deemed advisable to carry out exploratory work in the Chagres Valley in anticipation of possible requirements. The proposed storage site is Alhajuela, 10 miles above the mouth of the Chagres, and there are said to be other suitable sites on this river. A review of the situation was given recently by Mr. J. K. Baxter, of the Panama Canal Bureau of Statistics, in our contemporary the *Engineering News Record*. In this, Mr. Baxter put the maximum possible number of lockages per 24-hour day at 48, at which rate the tonnage handled might be of the order of 60 millions per annum. In the driest year yet experienced, 1920, the water available in the Gatun Lake in the dry season would have sufficed for 30 lockages per diem, with the Gatun hydro-electric plant out of operation, or 12 with that plant at 45 per cent. of full power. The Chagres storage scheme would not only render additional water available, but as it would include hydro-electric plant would render unnecessary the waste of so much water in this service at Gatun. The advantage is more than doubled, for not only would this water be saved to the lake, but the waste from the Chagres plant would still be available for use in locking vessels through. It is estimated that

the figure of 12 could be increased to about 48 lockages a day with the Chagres dam and the Gatun power station working at 45 per cent. capacity in the driest season. As the Canal is used at present by only 10 million tons of shipping the future seems to be well assured.

There were no serious accidents on the Canal in the year of the report. Several slides developed on the old sites, one such carrying 185,000 cub. yards of earth and rock into the channel so that it was partially blocked, though no inconvenience to traffic resulted. The total amount of excavation work accomplished in the year was 4,155,700 cub. yards. With the exception of 105,700 cub. yards, this was all maintenance work on the Canal, the bulk of it being in the Gaillard Cut (1,436,000 cub. yards) and the Pacific Channel (2,597,000 cub. yards). The campaign against the water hyacinth has been continued, and it is estimated that nearly 8,000,000 of these plants have been destroyed during the year by spraying.

All locks were in regular service during the year, except one flight at Miraflores which was out of commission for overhauling for about four months. The Miraflores steam-generating station was held in reserve throughout the year, and was called upon to supply current on 15 occasions.

CORROSION PROBLEMS.

A PAPER on "Corrosion as Affecting Metals Used in the Mechanical Arts" was read on Tuesday, the 5th inst., before the Sheffield Association of Metallurgists and Metallurgical Chemists, by Dr. W. H. Hatfield, Brown-Firth Research Laboratories, and past president of the Association. The object of the paper was to give the particulars and results of an interesting set of experiments made at the laboratories in question to decide upon the resistance of typical industrial metals to various corroding agents. Dr. Hatfield referred to former work in the matter of various steel alloys, including that by Brearley in regard to stainless steel, and added that acid tests—the means generally employed—gave no direct indication, unfortunately, of the usefulness of an alloy for general corrosion-resisting purposes. A 30 per cent. nickel steel was very resistant to sulphuric and hydrochloric acids, but was rapidly soluble in nitric acid of 1·20 specific gravity. The 14 per cent. chromium steel was readily soluble in hydrochloric and sulphuric acids, but insoluble in nitric acid, whilst the 15 per cent. silicon steel, although practically insoluble in all three acids, could not be considered completely rustless. These outstanding facts largely led to the carrying out of the experiments.

The materials dealt with numbered over 20, and in addition to pure irons, carbon steels, alloy steels, cast-iron, they included ni-chrome and a good selection of non-ferrous metals. The analysis of each was given, together with the mechanical properties, microstructures and the results of standard acid tests. A special table gave the results upon the specimens of total immersion in running water and of alternately wet and dry tests, in both cases for 30 days, and the results following exposure to steam at 100 deg. C. in the presence of oxygen during one week. Dr. Hatfield called attention to the fact that the atmosphere in industrial towns by no means consisted purely of oxygen and nitrogen.

He drew the two following conclusions: (1) There were now available steels and alloys which could effectively resist ordinary corroding influences. The different alloys, whilst at times each resisting the same media did not give the same response to other media. It was essential in the application of corrosion- and acid-resisting alloys for actual practical experiments to be made in connection with the particular application intended, since not only composition, but also concentration, temperature and extraneous influences had to be considered. (2) There was no obvious law, or set of laws, at present available, nor was any existing working theory sufficiently satisfactory to render effective aid to the investigator. In this connection Dr. Hatfield gave due recognition to the valuable work carried out by Dr. Friend, Dr. Bengough and others.

In regard to determining the relation which might exist between the electrode potential and solubility, it being understood that solubility was a function of electrode potential, the author said the main remarks to be put forward were: (1) When rapid solution took place the potential was highly negative; (2) when the potential had a high positive value very little corrosion or chemical action took place; and (3) otherwise the magnitude of the potential gave no indication of the solution properties of the metal. Another point worthy of note was the fact that in those cases in which rapid corrosion took place with evolution of gas, the potentials in hydrochloric and sulphuric acids were approximately the same, whilst in the case of the normal acids (acids containing 1 gramme of available hydrogen per litre) the potential in nitric acid was about 0·2 volt less negative than in the other two acids. No satisfactory explanation of these observations could be put forward. The history of the metal would have some influence on the measured electrode potential, as shown by a table included in the paper. The paper concluded with data on the carbides obtained in stainless steels, and with an appendix dealing with the measurement of electrode potentials.

The discussion was opened by the president, Dr. Baker, who stated that the author had given an enormous amount of data but had omitted to tell the meeting anything concerning the corroding effect of atmospheric air. He (the speaker) thought, however, that this would prove an exceedingly difficult test to carry out. With regard to the "exposure to running water" test, he would like to know what sort of water was used. In the case of the "alternate wet and dry" experiment, there was the question of the automatic removal of the rust during the course of the experiment. The difference in weight, before and after, was hardly sufficient, he thought, and further particulars would be desirable. Referring to mining waters, Dr. Baker said that ferrous sulphate and copper sulphate were frequently present and had a decided corroding effect. He further stated that 30 per cent. nickel steel was unsatisfactory, and gave an instance in which a mining pump rod made of this material proved quite satisfactory for a time, then began to corrode and suddenly failed. The high chrome steels were an interesting series; they certainly resisted certain types of corrosion, but none of them resisted them all. Dr. Hatfield had not mentioned the copper-steels, much advertised in the United States as being anti-corrosive. Quite a number of the American steels contained an unavoidable percentage of copper, and he thought it was quite probable that American steel makers boomed them as anti-corrosive in order to enhance their value.

Dr. F. Swinden laid stress upon the exhaustive and careful research carried out by Dr. Hatfield, and asked him to give also a paper on "Stainless Steel and Stainless Iron." He further said that the application of the high chromium stainless steels was quite well known, and their practical usefulness generally accepted. He fully realised that, provided this material be properly heat-treated, one could do anything with it. The whole point of its usefulness, however, lay in its price, and he asked Dr. Hatfield if he would discuss the subject from a financial point of view. He hoped that the new method of making low-carbon ferro-chrome by blowing hydrogen through ordinary ferro-chrome would prove a success and stated that this might have a bearing on the price of stainless steel. He further asked whether the author had investigated the effect of a solution of ammonium nitrate on the materials under discussion.

Mr. J. F. Kayser was surprised that Dr. Hatfield had not mentioned the series of super acid-resisting alloys brought out by Elwood Haynes, which were similar to ni-chrome, except that the nickel was replaced by cobalt. Some of these alloys also contained tungsten. He regretted that the ni-chrome alloy used by the author in his experiments was a forged sample, and maintained that cast ni-chrome alloys were far superior, from an anti-corrosion point of view. They resisted vinegar and citric acid, but did not, however, resist ammonium chloride. The alloy was, seemingly, not attacked to any appreciable extent, but solutions of ammonium chloride in contact with it always became discoloured. When speaking of thin, malleable stainless steel sheet, Dr. Hatfield had said that the material had been freed of all scale and was ready for pressing and polishing. He (the speaker) contended that it would be preferable to supply this material polished. Birmingham manufacturers, for example, would much prefer polished to unpolished sheet. The nature of the surface of stainless steel was the all-important feature in resistance to corrosion. Krupp's were endeavouring to produce a material which would be altogether rustless, by making a blend, as it were, of the ni-chrome alloys and stainless steel. In such a material, the nature of the surface did not matter.

Dr. F. Rogers, while agreeing that atmospheric corrosion was a highly important subject, said that it was a test exceedingly difficult to reproduce in a laboratory. He had tried to evolve several methods and stated that, obviously, the three most important factors to be taken into account were: (1) Temperature, (2) moisture, and (3) dust. He here exhibited two slides; the first showed a micro-specimen which had been partially polished and left for a few days. The specimen was covered with dust and the speaker pointed out a piece of fluff, probably cellulose, lying on the surface. This accumulated deposit was removed by lightly brushing with a camel-hair brush; the second slide showed a distinctly corroded spot where the piece of fluff had been. Referring to the celebrated Delhi iron pillar, Dr. Rogers said that it was not scaled because there were several agencies at work. The rain which fell in those regions was probably fairly pure water and, in the majority of cases, evaporation set in very quickly. Consequently, little rusting occurred. Again, in those latitudes, the temperature of the atmosphere was uniformly high at a distance of 1,000 ft. or even 2,000 ft. above the earth's surface. This air was continually in motion and contained suspended dust. This, he suggested, had a kind of slight sand-blasting effect, and, in his opinion, a balance existed between the tendency of the pillar to corrode and the tendency of the suspended dust to remove oxide. Dr. Rogers then described a piece of apparatus designed by him for the determination of atmospheric corrosion. This consisted of a bell-jar filled with an acidified atmosphere and in which the specimen was placed immediately below a jet. By means of the latter, a stream of sand, powdered glass, or any other substance could be trickled on to the specimen. Generally speaking, the continual exposure of the surface by sand aided the action of the acid.

Captain Armstrong asked whether all the samples of stainless steel were heat-treated, and also why stainless iron was not mentioned. The next speaker, Professor C. H. Desch, stated that he was afraid that they were little nearer the solution of the problem of corrosion, and that no general conclusion with regard to that problem could be arrived at from the figures supplied. It was a question presenting enormous difficulties. It seemed that, given correct heat-treatment, stainless steel was inert. With regard to the corrosion of some of the non-ferrous metals and alloys, according to theory aluminium should corrode much more quickly than iron. The former metal, however, although quickly acted upon by the atmosphere at first, resisted much better than iron because a layer of aluminium hydroxide was formed on the exposed surface, which protected this from further corrosion. In reality, it was the hydroxide which resisted corrosion and not the metal itself. This, however, did not hold if aluminium were exposed to the atmosphere in a tropical climate, or subjected to the action of sea water. The protective coating was destroyed and rapid corrosion set in. Army water bottles made of aluminium were soon rendered useless in tropical Africa, and aluminium alloys which had proved quite satisfactory in land aeroplanes rapidly corroded when used in the manufacture of seaplanes. Brass was rapidly attacked by sea water, and it had been found that the addition of 1 per cent. of tin lessened the corrosion. This was not easy to explain but, by means of the microscope, it had been ascertained that a brass containing tin actually corroded faster at first than one free from tin. Subsequently corrosion was very much retarded and this was due to the production of a basic oxy-chloride of tin which surrounded the metal with a protective and tenacious varnish-like coating. Wrought-iron was found to resist corrosion fairly well in India—another instance of the protection afforded by an oxide

film. With reference to the Delhi pillar, a piece of it brought to England was found to rust just like any other piece of similar material. There were many theories as to why the pillar did not corrode, but he considered the most likely one was that it was a sacred pillar, and, as such, was periodically anointed with molten butter. This treatment had continued for centuries, and no doubt accounted for its unscaled appearance. Turning to electrochemistry, Professor Desch stated that the relative position of a metal in the electro-potential series seemed to bear no relation to the liability of that metal to corrode.

Mr. Bolsover said the atmospheric test presented great difficulties in industrial towns and, in this connection, it might be mentioned that the Brown-Firth research laboratories were situated close to a sulphuric acid plant. Even exposure to country air had its difficulties. Many of the remarks had centred round the theoretical aspects of corrosion, and he would like to remind them that there were so many influences affecting corrosion that it was impossible to give any general conclusions and theories. The loss in weight of samples subjected to various corroding influences was a useful guide, but the appearance of the samples themselves was very helpful. The systematic treatment of materials in various media, the result of which had been put before the meeting, had never been done before and was, he maintained, highly useful.

Dr. F. Rogers endorsed the last speaker's remarks, adding that it was necessary first to carry out the acid and other ordinary tests and only then was it possible to proceed with specialised and intensified treatments.

In his reply to the discussion, Dr. Hatfield stated that he wished to thank, among others, Messrs. Bolsover and Stansfield for their assistance in the research work described. With regard to some of the points raised by Dr. Baker, the question of atmospheric corrosion had been dealt with by Mr. Bolsover. An appreciable quantity of sulphur trioxide was found in the atmosphere near their laboratories. He was glad to note Dr. Baker's remarks as to the unreliability of 30 per cent. nickel steel; similar unreliability had been found all over the world. In connection with copper-steels, it was not claimed by the Americans that an alloy of copper and iron was more acid-resisting than iron by itself; what was claimed was that the addition of 0·15 per cent. to 0·20 per cent. of copper to a steel rendered it more effective in resisting rust. He was of opinion that the influence of copper was very slight; he had tested samples of steel containing small percentages of that metal which seemed to have a good effect. The advisability of increasing the proportion of copper up to 1 per cent. was a very debatable point. In answer to Dr. Swinden, he said that the corrosive action of ammonium nitrate solution had not been tried. The price of stainless steel was not a subject which he cared to discuss at a scientific meeting, but, he contended, it was impossible to introduce a high percentage of chromium into a steel without greatly increasing the cost. The cost of cobalt and other metals used by Elwood Haynes made the latter's alloys far too expensive for use in the mechanical arts. Polished sheets of stainless steel could be, and were, supplied to manufacturers. The scale-free surface lent itself particularly well to polishing. Replying to Captain Armstrong, Dr. Hatfield said that all the samples of stainless steel submitted had been heat-treated. He agreed with Professor Desch that the position of a metal in the electro-potential series bore no relation to its liability to corrosion.

ROAD CONSTRUCTION.

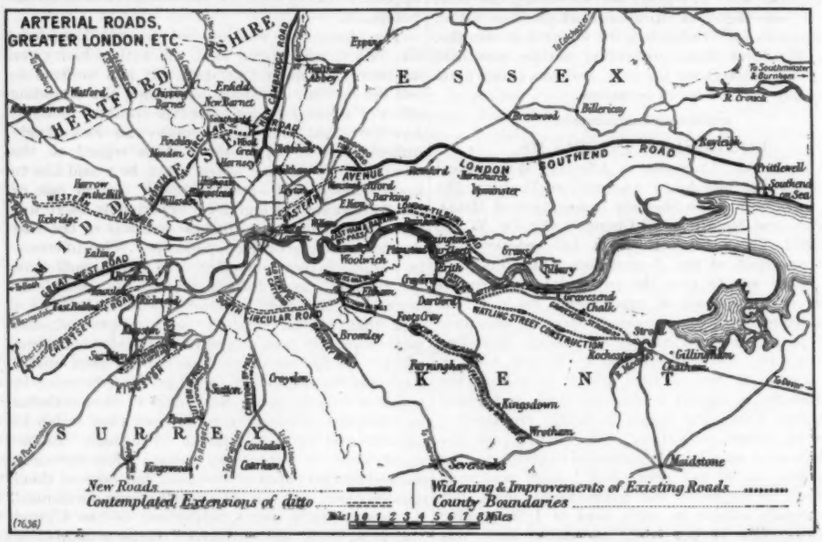
There will be few people willing to deny the undoubted value to the country of the Road Branch of the Ministry of Transport. We have suffered far too long from the policies or inaction of small sectional authorities, and whatever else has resulted from the invention of this expensive ministry, benefit to our roads has undoubtedly followed from its work. For the first time in our history we have an authority whose influence can be set at work all over the country with a view to conciliating conflicting interests, advising the smaller bodies whose views are naturally parochial rather than national, and doing many other things to reduce chaos to order with a view gradually to building up a consistent and uniform policy and road system, which, in the future, should prove of immense value.

The report of the administration of the Road Fund for 1921–22, just issued, shows what progress has recently been made in these directions. In the last couple of years the unfortunate conditions prevailing as regards unemployment have enabled more work to be undertaken than would have otherwise been the case. While relief measures of this kind are open to criticism, and need the most careful scrutiny, it must be admitted that road building on undeveloped land allows of the employment of a large proportion of unskilled labour, and is therefore a suitable class of work if the road planned is also an imperative necessity. In urban areas the question is different, and the value of the relief work afforded is reduced. It may be noted that in the report now before us the output in certain cases is described as having been unexpectedly high, and it is satisfactory to think that some proportionate return is being made, in at least some cases, for the relief thus given from want and distress. We wish the remark could be applied to all relief schemes.

In 1921–22 the receipts of the Road Fund totalled 12,585,633*l.* This amount for the first time included the results of twelve months' operation of the new method of motor vehicle taxation. From this source a sum of 10,795,000*l.* was derived, while Exchequer grants in connection with road schemes, brought forward earlier than originally intended, amounted to 1,203,000*l.* The gross collections under the motor taxation regulations in the calendar year 1921 amounted to 10,212,000*l.* Deducting refunds and cost of collection, &c., the approximate net revenue for Great Britain for the year was 9,000,000*l.* Payments made from the Road Fund in 1921–22 totalled 10,071,078*l.*, while, allowing for loans repaid, the net payments amounted to 9,922,393*l.* The bulk of the expenditure is by way of grants, in connection with the classification scheme for roads and bridges. These grants are towards the maintenance and improvement of works in the Class I and Class II road schemes. This classification is now complete, and grants are made up to 50 per cent. of the maintenance and improvement in the case of Class I works and 25 per cent. of the cost in Class II roads and bridges. In special cases where the district is sparsely populated but for some reason or other has become much frequented by motor traffic, exceptional grants have been made up to 75 per cent. of the cost of the work. The total grants under the classification scheme made in the year amounted to 8,108,027*l.*

Next in importance are the unemployment schemes, in connection with which grants amounting to 4,531,103*l.* were made. It will be remembered that a special fund of 10,400,000*l.* was formed for this purpose, consisting of a contribution of 4,000,000*l.* from the Road Fund, an Exchequer grant of 1,200,000*l.*, and loans available up to 5,200,000*l.* Later it was decided to allocate a further 2,000,000*l.* from the Road Fund for this work. Under the original scheme loans were not taken up to any extent. The allocations made amounted to 3,985,000*l.*, the bulk of which came directly from the Road Fund. Under the additional scheme 1,077,000*l.* have been allocated to unemployment relief on arterial road schemes in the London district, and 1,935,000*l.* to other road works in the provinces. These sums, with the contribution of the fund under the original scheme, make up the total of 6,000,000*l.* to which the fund was committed in this connection.

During the period involved the Unemployment Committee under Lord St. Davids received applications concerning 1,504 relief schemes. Most of these were local, and came under the committee, but in 164 cases the Ministry of Transport made grants from the Road Fund, and these are involved in the sums referred to above. The report gives a map, which we reproduce herewith, showing the works towards which contributions are being made



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The 1920–21 schemes include the Eastern Avenue, Western Avenue, North and South Circular Roads, the new Cambridge road and important by-passes. The Eastern Avenue has a length of about eight miles, and runs through Wanstead, Ilford, Romford, etc. At the end of March this road had been formed and graded in Ilford and Romford, and sections had been completed in Hackney and Leyton. On the Western Avenue the section through Acton has been completed, and work is continuing in Hammersmith. The Sudbury spur was nearing completion at the time of the report.

The North Circular road has been located over its whole length of 18 miles. Nine miles of this road are being or have been constructed, sections having been completed in Willesden and Walthamstow, and work is in progress in Hendon, Finchley, Southgate and Edmonton, &c. The South Circular road has shown less progress, as most of it is through built-up areas. This work does not lend itself to the employment of unskilled labour, and only a small section of the road in Woolwich has been touched. On the new Cambridge road work is approaching completion in Tottenham, Edmonton and Enfield, and the whole length so far as Hertfordshire is concerned is now in hand. This road will join the old Cambridge road at Turnford. The two important by-passes put in hand in 1920–21 were that at Eltham and that at Shooters Hill. On the first considerable progress has been made in substituting a 48-ft. by-pass for the original road. This work is three miles long, and is approaching completion.

The second group of works includes the London-Tilbury road, the London–Southend road, Watling-street, Dartford–Gravesend road, Gravesend-

in the London district. These fall into two classes. The first comprises arterial schemes inaugurated in 1920–21 to mitigate unemployment. The second comprises work put in hand in the season 1921–22.

Strood, and Sidcup–Wrotham roads. These works have been undertaken under rather uncommon conditions. The object at the time of the inception of the schemes was to find employment for men out of work in the County of London. Owing to the built-up character of the land within that area, work had to be found outside, and plans were considered by the Ministry of Works costing £2,250,000, towards which the London County Council agreed to contribute up to £500,000 if unemployed men in its area were utilised. In connection with the Southend road, Southend agreed to contribute £100,000 if part were reserved for unemployed men in its area. Contributions were also made by East and West Ham towards part of the Eastern Avenue, and by the County Councils of Kent and Essex to roads in their areas. The whole of the schemes were directly undertaken by the Ministry of Transport, which has let out the work to contractors. The schemes have involved the daily transport of labour to points some of which are 30 miles from London, and suitable provision has had to be made in the way of canteens, and so on. The whole of the arrangements appear to have worked extremely well, and the work accomplished is reported to be good.

Of these roads the London–Southend road has given employment to about 2,000 men. This road is about 21 miles long and 100 ft. wide, and is a direct continuation of the Eastern Avenue, with which it forms a modern highway totalling 30 miles in length. At present only one carriageway is being laid down. This road has been located so as to obviate the demolition of property, and it is stated that in some cases the necessary land has been given by the owners. It is an entirely new highway passing south of Brentwood, Billericay, Wickford and Rayleigh. Thirteen miles are now in hand. The London–Tilbury road will provide much-needed improvement in the means of communication between Tilbury Docks and London. This road is a continuation of the East Ham and Barking by-pass. The extension involves the widening of the Barking–Rainham road, and of new sections, avoiding Wennington and Purfleet. At the latter point two level crossings are thus cut out. The new road joins the old about three miles west of Grays. The whole of this scheme is in hand.

The Watling-street scheme covers about 11 miles, and includes for the most part the widening between Dartford and Rochester of the old Roman road. The work will also involve the reconstruction of a missing link in the road over Swanscombe Hill. The ancient road was taken up this hill on such a steep grade that it was abandoned hundreds of years ago. This length will now be restored, and a deep cutting through the hill will provide the improved road with a much easier gradient. The Dartford–Gravesend scheme involves widenings, stretches in the districts of Stone and Greenhithe being now in hand. The Gravesend–Strood road involves widenings, except for a small distance at the Gravesend extremity. The work on this scheme is, we believe, all in hand. The length involved is rather more than six miles. An important improvement is covered by the Sidcup, Farningham and Wrotham road. This work consists of widenings, with a useful new by-pass at Farningham and a cut-off at Wrotham. The work commences at Roxley Corner, and the by-pass at Farningham, while adding slightly to the distance, avoids dangerous village streets and cross-roads. The Wrotham cut-off passes north of that village, and thus avoids some extremely dangerous junctions which road users will be glad to escape.

In addition to the above, construction is in hand on an extension of the Great West road from the Bath road down into the Basingstoke road. Work is also in hand on a road from Chiswick to Chertsey, passing through Richmond, Twickenham, Hanworth and Sunbury. This will involve expensive work, which for the present must be deferred, but a commencement has been made on the scheme in Chiswick. Another important work is the Croydon by-pass, which is now approaching completion, the principal work remaining being on bridges over the railways, and the surfacing of the roadway.

In other areas the most important works include new roads and widenings in Birmingham, costing £120,000; two routes of first-class importance in Glasgow, involving widenings, costing £80,000; a new road between Rotherham and Sheffield; and many programmes covering widenings, the easing of corners, and other improvements, scattered over the country.

NOTES.

BROWN COALS AND LIGNITES.

PROFESSOR W. A. BONE, of the Imperial College of Science and Technology, concluded his series of three Cantor Lectures on "Brown Coals and Lignites" at the Royal Society of Arts, on Monday last, with a statement of the success attending their use in low temperature carbonisation, in gas producers and for steam raising. Of the three purposes for which carbonisation is useful—up-grading the fuel, separating the volatiles, condensable substances and ammonia, and the utilisation of any gas available, the lecturer stated that the first was the most important at the present time, and showed how a "fuel improver" might be incorporated in the boiler equipment and heated by the waste gases of the boiler (see ENGINEERING, vol. cxiii, page 257). The results obtained with this device are said to be successful if air-leaks are prevented. The results of preliminary carbonising tests with a small glass tube retort show considerable differences in yields of liquors, oils and tar, and of gas, from those obtained with bituminous coals. The construction of a boiler furnace to burn brown coals must be so formed as to ensure the use of radiated heat to keep the fuel at a high temperature. Firebrick arches for this purpose have been used with considerable success. In ENGINEERING, of March 17, 1922, we illustrated such a boiler-setting as successfully used in Western Canadian power stations to burn the local lignites of Alberta. Professor Bone spoke of attempts to burn these low-grade coals in an ordinary boiler furnace, and suggested that a lot of prejudiced opinion regarding the value of these fuels had been founded on failure in such endeavours. He blamed engineers whole-heartedly for their indulgence in this type of "research," although the fact that other engineers in various parts of the world can claim to have found means of modifying the combustion chambers of boilers to permit the successful combustion of these and other low-grade fuels, is evidenced by the setting above referred to.

PUBLIC TENDERS.

A London periodical, which does not deal with metallurgical or engineering subjects, once published a cartoon depicting a successful contractor whose tender for a contract had been accepted as being the lowest; he was represented as exclaiming: "Where, now, have I made a mistake?" This, we may point out, was pre-war, when the conditions, compared with those now ruling, were practically normal both in regard to material and labour. The illustration we refer to came to our mind when looking through the lists of tenders published this week by the London County Council. One contract is for the supply of the necessary switch gear, &c., for No. 4 turbo-generator at Greenwich power station. The lowest tender, that of Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, was for a total of 1,441*l.*; 10 firms sent in their offers, the highest tender being 1,969*l.* Nineteen other firms sent in offers for the construction of a sludge vessel; in this instance, the lowest tender, that submitted by Messrs. William Beardmore and Co., Limited, Dalmuir, was for 48,000*l.*, whilst the highest amounted to 76,000*l.* In a third instance, the enlargement of the Isle of Doga pumping station, there were, also, 19 tenders, the lowest figure being 29,114*l.* and the highest 65,792*l.* The difference in the totals quoted for the same work is very great indeed, as will be noticed. We do not suggest that errors have been committed in the computations made by the different works, although this, of course, is possible. The great discrepancies appear to us rather to illustrate the embarrassments with which a large number of works are now beset, owing to the difficulty of obtaining a regular supply of raw material at reasonable cost, and to labour requirements and, especially, the uncertainty of the industrial position. Another point which should not be lost sight of in this connection is that several of the firms who quoted may have done so without regard to profit, and special conditions particular to themselves may have led them to endeavour to procure employment for their men and plant, pending other possible contingencies. There are many precedents to justify this latter impression.

THE NEW CAPITAL SHIPS.

The Prime Minister announced in Parliament on Monday last that the Government had decided to proceed at once with the construction of the two new capital ships which this country is allowed to build in accordance with the terms of the Washington Treaty. The contracts for the construction of the hulls have been allotted to Messrs. Armstrong, Whitworth and Co., Limited, Newcastle-on-Tyne, and to Messrs. Cammell, Laird and Co., Limited, Birkenhead. The last-named firm will construct the machinery for the ship they are to build, but that for Messrs. Armstrong's ship will be constructed at Newcastle by the Wallsend Slipway and Engineering Co., Limited. Messrs. Armstrong's will, however, construct part of the gun-mountings, the other part being made by Messrs. Vickers, Limited, at Barrow-in-Furness. The armour will be made in Sheffield, Manchester and Glasgow, in which districts some of the guns will also be manufactured, orders for the remainder of the guns being distributed between Barrow, Newcastle, Darlington and Woolwich. About three years will be required to complete the vessels, the total cost of which is estimated at £12,000,000, and of this sum about £10,000,000 will be absorbed in wages. A very material reduction in the existing unemployment will thus result from the placing of these orders, so that the Government's decision to put the work in hand at once is to be commended on this ground, as well as from the no less important standpoint of national security. The two new vessels, it will be remembered, are to be built in place of the four capital ships, the construction of which was authorised in 1920, but was subsequently abandoned after the agreement as to the limitation of naval armaments had been reached at Washington. The new ships will be smaller than those previously designed, their displacement being limited to 35,000 tons each by the terms of the Treaty, whereas the earlier designs were for vessels displacing 45,000 tons each. When completed, they will be the only two capital ships of post-Jutland design in the British Navy, our present latest capital ship, the Hood, having been designed and partly built before that engagement took place, although its construction was somewhat modified before completion. Assuming that the Treaty is ratified by all the Powers concerned, the United States Navy will include three post-Jutland ships, and the Japanese Navy two, so that the completion of the two new vessels is essential to the attainment of the "one-power standard" of naval strength which is rightly regarded as the minimum possible for this country.

THE HOT-WIRE MICROPHONE.

The hot-wire microphone is an instrument in which the air pulses constituting sound are made to exercise a cooling effect upon a fine platinum wire maintained normally at a bright red heat by an electric current. The variations in the temperature of the wire modify its electrical resistance, so that when the instrument forms one arm of a Wheatstone bridge, the sound waves can be recorded by means of a sensitive galvanometer. It was invented by Major W. S. Tucker, R.E., during the war, to detect enemy guns, and for this purpose it consisted of a cylindrical sheet-metal box with blunt conical ends. In the centre of one end was an orifice about 0·25 in. square, in which the grid of fine platinum wire was supported. When the sound wave reached the orifice it caused a blast of air through the grid with the effect above-mentioned. The instrument is extraordinarily sensitive, but it is also very selective and responds best, as might be imagined, to low notes. Its properties were demonstrated by the inventor in a lecture before the Royal Society of Arts, on November 29, and the post-war applications of the principle to commercial and scientific uses were explained. Much work has been done in collaboration with the Admiralty and Trinity House, on the range of sound

from sirens and fog horns. By suspending a person on a scale pan hanging from a sound-box, and connecting the sound-box by means of a pipe to the microphone, records of heart-beat could be readily obtained, and any irregularity in the action of the heart due to drugs, alcohol, disease or fatigue could be noted with certainty. A very large number of slides were shown, illustrating photographic records of various sounds, many of which were inaudible to the observer at the time the records were taken. By taking advantage of the principle of resonance, the effect of sounds could be enormously magnified, and at the same time a high degree of selectivity obtained, the instrument being quite unaffected by all sounds varying more than 5 per cent. or 6 per cent. from the frequency of the resonator containing the hot wire. In connection with the suppression of sound it had been found that the fibrous vegetable skeleton, known as loofah, was most efficient, and as an incidental experiment it was shown that a candle could be blown out through half an inch of felt, whereas it was quite unaffected when the felt was replaced by loofah. This was the more striking as light could be seen through the texture of the loofah. The intensity of the sound from a tuning fork in various parts of the lecture room was demonstrated by moving the microphone about and the existence of silent points shown. It is hoped by means of the instrument to place the science of acoustics on a sounder basis by providing a means of measuring sounds quantitatively.

Mechanical Transport in Roadless Countries.

In undeveloped countries where no roads exist, or where such roads as there are would be rapidly destroyed by ordinary wheeled traffic, there appears to be considerable scope for the employment of mechanically propelled vehicles, capable of travelling in any direction across country. A paper bearing on this subject was read before the Institution of Automobile Engineers, on Wednesday last, by Lieut.-Colonel P. H. Johnson, who dealt particularly with recent improvements in vehicles for roadless countries. Such vehicles, the author pointed out, had the greatest possible lateral flexibility, and could be used to develop wide areas of country, instead of comparatively narrow strips such as are served by roads and railways. To render their employment practicable, however, it would be necessary to obtain a degree of overall efficiency approximating to that of a wheeled vehicle working on bad roads, as well as an approximately equal degree of durability and reliability. With regard to efficiency, the author quoted the results obtained with the tanks used during the war, and stated that these vehicles, engaged on normal cross-country work, had an overall efficiency of about 7 ton-miles per gallon, whereas the average figure for a 3-ton lorry was about 45 ton-miles per gallon, with a tractive resistance of 60 lb. per ton. The poor performance of the former he ascribed to lack of power to contend with obstacles, excessive weight, access of mud, etc., to the bearings, the method of steering by skidding, and excessive flange friction. To overcome these difficulties, the author described a method of suspending the vehicle by ropes and springs so that a perfect distribution of the weight on the track in contact with the ground would be obtained. Suspended in this way, he stated, a vehicle of the type referred to, travelling at a speed between 20 and 25 miles per hour, could pass over two sleepers placed one on top of the other, without imparting any perceptible vertical movement to the chassis. With this form of suspension, he added, it had been found possible to reduce the weight of the track shoes and links to less than 14 lb. per foot run. The protection of bearings had been improved so that a 7-ton vehicle, with a draw-bar pull of 3 tons, had been run for 500 miles over sharp sand without measurable wear. In connection with steering, the author mentioned that improved methods had enabled the excess power to be reduced from 150 per cent. to 20 per cent. above that required for travelling in a straight line, the 7-ton vehicle above referred to being capable of travelling in a curve of 35-ft. radius without perceptible skidding. Flange friction had been reduced by connecting the track plates by single control links of circular section, upon which the rollers supporting the weight of the vehicle ran. The machine, he said, could travel across country at an average speed of 10 miles per hour, and would give over 21 ton miles per gallon. This figure would compare favourably with that for an average 3-ton laden lorry travelling on bad roads, and having a tractive resistance of about 140 lb. per ton.

Fatigue in Metals.

In a paper read before the Royal Aeronautical Society, on the 7th inst., Professor C. F. Jenkin dealt more fully with the interesting model devised by him to illustrate the behaviour of metals under tensile, compressive and alternating stresses. The model and its applications were illustrated and described by Professor Jenkin in an article published in our issue of November 17 last, on page 603, to which we must refer our readers for full particulars, but some experiments on the fatigue of metals suggested by the use of the model and dealt with in Professor Jenkin's paper are of sufficient interest and importance to be briefly mentioned here. If the case of a metal subjected to an alternating stress be considered, it will be evident that a greater force will be required to shear a crystal than would suffice to keep the parts slipping one over the other after the shearing had occurred, *i.e.*, the adhesion between the surfaces would be greater than the friction between them. The effect of adhesion can be shown by the model by making the sliding blocks grip a collar on the rod in such a manner that they will slip off the collar when the force applied is greater than the adhesion. From a five-unit model modified in this way and arranged to represent axle-steel, Professor Jenkin obtained a graph for the range of stress plotted on a base representing the inferior stress limit. The graph falls in a series of steps from a value of 25 tons per square inch with an inferior limit of — 12 tons per square inch, to 19·5 tons per square inch with an inferior limit of about 20 tons per square inch. The steps would, however, be replaced by a straight inclined line falling from 25 tons to 19·5 tons if a model with a sufficiently large number of units were employed. The increase in the fatigue range as the inferior limit is reduced would be due to the effects of adhesion, and if the adhesions could be broken down, the fatigue limit would be reduced to the value of 19·5 tons per square inch. This Professor Jenkin did by overloading a specimen of the steel under alternating stress and gradually reducing the load, this treatment breaking down all the adhesions and leaving the crystals in a stress-free condition. Tested in this condition, the fatigue limit should thus be some 25 per cent. lower than in the normal condition, and in an actual test with a 0·33 per cent. carbon steel the author found the limit to be reduced by 29 per cent. Another experiment carried out on the same steel is particularly interesting. It will be evident that if the steel, in its stress-free condition, could have the adhesions restored, the fatigue limit would be raised above the normal value. This Professor Jenkin effected by boiling a specimen in water for two hours, after having freed it from stress as above described, this heat treatment causing the crystals to heal and restoring their adhesion. The specimen tested subsequently was found to have a fatigue limit 21 per cent. above the original value, thus confirming the predictions made the behaviour of the model. The experiments also serve to show the relationship between adhesion and friction, the ratio for the particular steel tested being 1·7. In several other respects referred to in the paper, the actual behaviour under stress of metals such as iron, steel, nickel and copper, can be accurately predicted by the model, which, it should be noted, will give quantitative as well as qualitative results. Professor Jenkin also considers that it could be applied to investigate fatigue in shear, but this has not yet been definitely ascertained. He thinks, however, that the behaviour of brittle materials, like cast iron, may be different from that represented by the model.

Correspondence with Swedish Firms.—The Commercial Secretary to H.M. Legation at Stockholm draws the attention of the Department of Overseas Trade to the inadvisability of corresponding with Swedish concerns in the German language, and suggests that, if firms are not in a position to employ the Swedish language in correspondence, catalogues, pamphlets, &c., then the English language should preferably be used.

INDUSTRIAL NOTES.

It is announced that a national delegate conference of the Miners' Federation is to be held in Southport on Thursday, the 21st inst., when a report of the negotiations with the owners and the Government will be put before the district representatives and discussed. Speaking last week in Parliament in reply to a question, Mr. Bonar Law stated that he was not prepared to adopt the suggestion to bring in legislation for the nationalisation of the mines and the State ownership of minerals, as recommended by the Coal-Mining Industry Commission appointed by the late Government. This point will no doubt be among those to be discussed at Southport. In the meantime the export coal market is very active and would be more active still were the means available at the South Wales docks better able to cope with the demand. The trade unions concerned with ship loading and dispatching have received urgent appeals to revert to the three-shift system so as to facilitate the trade, but hitherto these appeals have met with no response. The Mining Association issued last Tuesday a statement in which they say that cases of hardship in the coal industry are exceptions; they add that the men's leaders are trying to make the people believe that the conditions in those exceptional cases prevail throughout the industry Such is not the case, since as compared with other industries the coal industry is in a relatively good position, and it is time the public knew the facts. The average weekly wage for all classes employed at the collieries in the ten years 1904–1913 was 29*s.* 9½*d.*; the last average figure, for October last, was 50*s.*, which represents an increase of 68 per cent. In their comparisons, the men's leaders omit to state that in 1913 and 1914 wages were at a relatively high level. Mr. Hartshorn has said that the 1914 wage was 5*s.* or 6*s.* a week above the subsistence level; this corresponds to 20 per cent. above the subsistence level. If this is so, the present figure, the statement further adds, represents an increase of about 85 per cent. above the subsistence level of 1914, and it should be compared with 80 per cent. increase in the cost of living. The statement also lays stress upon absenteeism and upon its effect on wages.

A supplementary estimate for 1,070,000*l.* for the relief of unemployed has been issued; it brings the total amount estimated for this purpose for the year to 2,570,000*l.*, and the total and all supplementary estimates presented to 17,622,202*l.*, compared with the Budget provision of 25,000,000*l.* Of the new amount, 50,000*l.* is a grant to be paid direct to the Forestry Fund. The remaining sum is required to meet expenditure in connection with schemes for the employment of labour on land improvement and drainage, for loans to local authorities to enable them to carry out approved works for the relief of unemployment, to distressed local authorities in exceptional cases for their general purposes, and to Poor Law authorities in necessitous areas who are unable to meet claims upon them for relief. The estimate was accompanied by a memorandum explaining that, of the 1,070,000*l.*, a sum of 600,000*l.* is for additional expenditure in respect of existing schemes, whilst the balance, 470,000*l.*, is the amount required in the current financial year in respect of new assistance, which will total 1,620,000*l.* in all. It is proposed to incur further expenditure amounting to 375,000*l.* for works services; 946,000*l.* in the advancement of Post Office capital works; and 1,500,000*l.* from the Road Fund.

The November ascertainment having shown that the average selling price of Bessemer mixed numbers of West Coast hematite pig-iron was 91*s.* 9*d.* per ton, an increase of 1*s.* 5*d.* compared with the previous month, Cumberland and North Lancashire blast-furnacemen's wages accordingly rise by 1 per cent., to 1½ per cent. above the standard.

We are informed that a distinct revival of confidence was noticeable at the weekly meeting of the London Iron and Steel Exchange on Tuesday. The difficulties which are besetting the Continental manufacturers have resulted in the diversion of many orders to the British works. In fact, the latter are probably better off for work now than at any time during the current year. The improvement in the demand for constructional iron and steel material is a particularly satisfactory feature of the situation. Most of the steel-making districts have benefited and this circumstance has helped to revive confidence. It is understood that a considerable volume of business is being held up in the expectation that Continental manufacturers will be in a position to enter the market again on competitive terms in a short time. It seems likely, however, that this reading of the situation is not the correct one as the difficulties regarding fuel which Continental

manufacturers are experiencing do not appear to be growing less. There has been a wide variation in the prices demanded for Continental material, but the general tendency has been for the lower range of quotations to disappear, and there is a noticeable inclination for the prices of British producers to stiffen. The quantities obtainable from Belgium, France and Germany have been limited of late and for the most part have been sold to old customers, probably with a view to retaining established connections. The representatives of British works on 'Change were confident that pending business would soon have to be placed, and that the greater part would go to the home manufacturers. Improved conditions were also reported by the producers of semi-finished material, and in this market definite price advances have been announced from South Wales. The pig-iron market continues to feel the restriction in business caused by the cessation of American orders. A few fresh inquiries continue to arrive; but in view of increasing production in the United States and much cheaper quotations it seems unlikely that many more American orders will be placed in Europe. The demand from home consumers, however, although quiet, appears to be expanding.

The last report issued by the Administrative County of London states that the Council is informed of an arrangement arrived at between the Association of Master Lightermen and Barge Owners (Port of London), and the Barge Builders' Trade Union, whereby the wages of barge builders will be reduced by 2*d.* an hour on and from January 1, namely, to 1*s.* 6*d.* an hour, with stabilisation at this rate until March 31 next. The General Purposes Committee has therefore recommended that the Council's list of rates of wages and hours of labour be amended by the substitution of 1*s.* 6*d.* for 1*s.* 8*d.* in the same way.

The journal for the current month of the Amalgamated Engineering Union states that the membership on January 1 was 409,219. At the end of November last it was 354,090, and 357,871 at the end of October last.

FLOATING DOCK FOR SOUTHAMPTON.—Following upon our announcement on page 493 *ante*, we are now informed that Messrs. Worthington-Simpson, Limited, Queen's House, Kingsway, W.C. 2, have secured a contract for the supply of 14 sets of centrifugal pumps for this dock. The approximate quantity of water to be pumped during the lifting of the dock is 80,000 tons, the time of lift being 220 minutes.

THE INSTITUTION OF CHEMICAL ENGINEERS.—The fifteenth meeting of the Provincial Committee was held on Wednesday, the 6th inst., at 166, Piccadilly, W. Sir Arthur Duckham, K.C.B., M.I.C.E., took the chair. The hon. treasurer's report revealed the fact that the balance at the bank and in hand would be insufficient to carry this Institution forward to the time when the first Council might be elected, and an appeal is to be made to the donors for a second instalment of their donation. It was stated that the Board of Trade had announced that the licence had been granted and would soon be issued. The next meeting of the committee was provisionally fixed for Wednesday, January 10.

RETORTS FOR OIL SHALE INVESTIGATIONS.—In the course of the oil shale investigations being conducted at Boulder, Colo., by the Bureau of Mines, a number of runs with the new vertical retort have been made for the principal purpose of determining if the oil produced with the vertical retort had the same properties as oil produced by the assay retort under the same conditions of rate of retorting and thickness of charge. While there are certain differences between oils produced under similar conditions with these two retorts, they are of unimportant nature and were probably caused by the greater difficulty of accurately regulating the temperatures in the vertical retort. This difficulty is expected to become negligible once the operators become more familiar with the working of the apparatus.

BRAZILIAN OIL SHALE INVESTIGATIONS.—Assay tests on a sample of Brazilian "turfa" have been completed at the Boulder, Colo., field office of the United States Bureau of Mines. This material is a soft brownish-yellow substance, having an apparent specific gravity less than that of water. It yields on distillation as much as 113 gallons of crude oil of 0·870 specific gravity, and, in addition, up to 6 gallons of scrubber naphtha per ton. The oil is of very good quality as shale oils go, and the material also gives a relatively high yield of gas. In retorting, the "turfa" shrinks to about one-third of its original volume, and forms a weakly adherent coke of probable fair fuel value. The effect of rate of oil production on the quality of oil is shown up very strikingly in the examination. For example, gasoline produced from oil made from this material at the rate of 1 c.c. per minute was 34 per cent. unsaturated, while the kerosene fraction of this oil was 41·5 per cent. unsaturated. From crude oil produced at the rate of 0·2 c.c. per minute the gasoline produced was 30·1 per cent. and the kerosene 33·6 per cent. unsaturated.

THE LATE COLONEL JOHN M. DENNY.

BRITAIN can still be proud of the fact that she still possesses some industrial organisations whose partners have that high sense of duty which prompts their enthusiastic endeavours for the welfare of their workers and for the good of the community. The firm of William Denny and Brothers, of Dumbarton, on whose activity the town so much depends, has always had among its partners some who were leaders in every form of social and philanthropic work. A founder of the firm, Peter Denny, LL.D., had this great sense of duty, and his son, Colonel John M'Ausland Denny, who died last Saturday in a Glasgow nursing home, preserved throughout his life the high traditions established by his parent. Dumbarton is in mourning for a chieftain for whom the affection of his workers, fellow-townsmen and those with whom he associated in business is reminiscent of that of the clansmen of old for their chief.

Colonel Denny was the fourth son of Dr. Denny, and was born in Dumbarton in 1858. He was educated in his native town and in Lausanne, in Switzerland. Following a course of training for the business side of shipbuilding, he entered the firm at the age of 17. A characteristic of the family—of training the younger members for those specific activities in the business for which they promised greatest fitness—was adhered to, and Colonel Denny began his career in the counting-house. Here he had to conform to the rules enforced

Photo by Lafayette.

THE LATE COLONEL JOHN M. DENNY.

on all other apprentices. The wisdom of these measures is borne out by the success attending their use. The Colonel knew his fellow-workers in the organisation as could never otherwise have been the case, and they appreciated him for his sterling worth. He was instrumental in obtaining many of the continental shipbuilding orders received by the firm, and spent a considerable amount of time in the business centres of Europe to keep in touch with foreign shipowners. The success of his early endeavours to obtain a portion of the continental trade awakened some of the foreign governments, and both the Germans and the Belgians made regulations that no building of subsidised ships could be allowed in other than their own lands. Colonel Denny took a part in 1901 in the co-operation of his firm with the Parsons Marine Steam Turbine Company in the production of the first commercial turbine steamer, the King Edward, which is still in successful use on the Clyde. From this beginning sprang the great development in this method of propulsion, in which Colonel Denny always took a part.

In 1919 he was elected chairman of the company. In this position he took a close personal interest in industrial questions and welfare work. His bright, genial personality won for him friends among all ranks and classes of men, and with his capability and enterprise he was able to maintain the world-wide reputation of his firm.

Colonel Denny was elected M.P. for the Kilmarnock District of Burghs, in which Dumbarton was then included, in 1895, and retained the seat in the Unionist interest until 1906, when he retired from his political work. His constituents, both Unionist and Liberal, marked the esteem in which he was held by presenting to him his portrait, painted by George Henry, R.A. As a Member of Parliament Colonel Denny rendered great service in all matters concerning shipping and shipbuilding, and served on important committees concerned with the treatment of seamen, and the causes of the increases of foreigners in the Mercantile Marine. He was an enthusiastic worker in the Volunteer movement, and joined in 1876 as a private, with many of the workmen of the firm of which he was a partner. Two years later he obtained his commission, and he rose to the rank of Colonel of the 9th Argyll and Sutherland Highlanders, after 19 years' service. During the war he acted as commanding officer to two battalions of the Territorial Force, and as Dumbartonshire Director of the Red Cross Society.

He was a director of the Caledonian Railway Company, the Commercial Bank of Scotland, and other companies.

THE INTERNATIONAL ELECTRO-TECHNICAL COMMISSION.

MEETINGS of the International Electrotechnical Commission Advisory Committees on Rating, Graphical Symbols, Standard Pressures and Regulations for Overhead Transmission, as well as screw lamp caps and holders, were held in Geneva, commencing Monday, November 20, and continuing until November 26, 1922. The question of the rating of electrical machinery occupied the major portion of the time, being the most important subject and the principal reason for the convening of the meetings.

Mr. E. Huber was elected to preside over the technical sessions of the Rating Committee, and arrangements were made for meetings of the other Advisory Committees to be held during the week. The main object of the meetings of the Advisory Committee on Rating, which was convened principally at the request of the British National Committee, was to consider the difficulties which have arisen in the attempt to introduce into practice the method recommended by the International Electrotechnical Commission of rating electrical machinery on the maximum continuous load. The British delegation stated that it had been found possible to adopt the International Electrotechnical Commission 50 deg. C. rating without overload for certain classes of machine, but for the ordinary type of industrial motor and generator the established British practice had for many years past been to rate these machines on a 40 deg. C. temperature rise with an overload of 25 per cent. for 2 hours. The British Committee had found itself in a difficult position in its efforts to be loyal to its industry and to the International Electrotechnical Commission as well; and this was the reason why it appealed to the International Electrotechnical Commission for assistance in finding a solution of the problem confronting it. The British were most anxious that an overload rating of this nature should be recognised by the International Electrotechnical Commission, and were moreover desirous that temperature rise alone should be specified and that the rating be based on the temperature rise at full load and not on the overload. In Great Britain it should be noted that the cooling air temperature does not exceed 30 deg. C., and indeed is more nearly 20 deg. C., and this overload therefore does not produce maximum temperatures in excess of those laid down by the International Electrotechnical Commission.

The British also felt that whilst established British practice in regard to industrial motors gives a more substantial machine than the 50 deg. C. rating of the International Electrotechnical Commission without overload, unless the International Electrotechnical Commission agreed to adopt an overload rating for this class of machine, the rating the British desired to standardise in their own country would not actually be in accordance with the International Electrotechnical Commission rules, although it might be within them. Some misunderstanding arose in regard to the question of the temperatures produced on the overload, as an overload rating, if adopted by the International Electrotechnical Commission, would have to be applicable to all countries where the ambient temperature does not exceed 40 deg. C. The British delegation, whilst emphasising the fact that the ultimate temperature limits of the International Electrotechnical Commission had been based on laboratory experiments carried out many years ago, and experience with the use of the modern materials and methods of measurement might justify a review of the International Electrotechnical Commission maximum temperature limits, yet at present they were most desirous of putting forward only such proposals as would be entirely within the International Electrotechnical Commission limits.

Some discussion then took place as to the necessity of the International Electrotechnical Commission introducing overloads seeing that any National Committee is perfectly at liberty to specify overloads in their national rules so long as this does not involve temperatures beyond the International Electrotechnical Commission figures. In view, however, of the commercial importance attached to this question by the

British Committee, the other delegations, desiring to give satisfaction to the British, after further discussion agreed to consider the question of recommending the introduction within the International Electrotechnical Commission limits of a nominal rating with an overload as an international standard.

In deference therefore to the British views, the Advisory Committee, with the help especially of M. Boucherot (France) and Signor Semenza (Italy), endeavoured to find a solution satisfactory to their British colleagues. The American delegates, whilst they had not come with any preconceived ideas or definite proposals, were at the same time inclined to favour the British suggestion, although they pointed out that there was a tendency in the United States towards a 40 deg. single rating without overload, which would imply a liberally designed machine capable of carrying both the mechanical and electrical overloads that such machines have to meet in ordinary service. They urged most strongly that one rating only should be adopted.

After much discussion a generally acceptable proposal embodying the wishes of the British delegates was agreed to for submission to the National Committees to the effect that overload ratings within the International Electrotechnical Commission maximum continuous rating be recognised and that, for general industrial machines (the class to be defined later), where overloads have to be provided, a machine having a 40 deg. C. temperature rise and capable of carrying 25 per cent. overload for 2 hours applied at the end of the full load run be recommended, the overload only to be applied under such conditions of air temperature as will not cause the limits of maximum temperature laid down by the International Electrotechnical Commission to be exceeded. It will be remembered that the main object of the international rating of electrical machinery is to establish an equitable basis of comparison of tenders, and much discussion took place as to the method of indicating the relation between the proposed British nominal rating and the International Electrotechnical Commission single rating. To carry this into effect Signor Semenza suggested, and it was ultimately agreed to recommend, that the rating plate of the machine should indicate, in addition to the other information, the output under the ordinary International Electrotechnical Commission continuous rating (50 deg. C. rise).

With this decision the meetings of the Advisory Committee were adjourned, and the British delegates expressed their thanks and appreciation of the manner in which their proposals had been received. They had fulfilled their obligation to consult the Advisory Committee before introducing into their national rules recommendations at variance with those of the International Electrotechnical Commission, and in view of the agreement now arrived at they felt, and the members agreed, that they would be at liberty to proceed with the urgently required revision of their national rules, introducing into the new British rules a lower temperature rise and an overload rating conforming as to ultimate temperatures with the International Electrotechnical Commission limits, and indicating at the same time on the rating plate the relation between their 40 deg. C. rating with overload and the International Electrotechnical Commission 50 deg. C. single rating. The German representatives said their desire was to resuscitate the German National Committee and its work, and, in so far as is possible, to bring the German rules entirely into harmony with the rules of the International Electrotechnical Commission.

A meeting of the Advisory Committee on Graphical Symbols was held, with Dr. Wyssling (Switzerland) in the chair. The proposals put forward at Brussels in 1920 were carefully considered and additional symbols were added. In the discussion the delegates had before them the graphical symbols issued by the British Engineering Standards Association (B.S.S. No. 108) and those of the Italian and Swedish and Swiss Committees.

A meeting in regard to standard pressures and regulations for overhead transmission was also held, and in this case Dr. Mailloux took the chair. With regard to the standard pressures recommended to the National Committees by the Advisory Committee at Brussels, the recommendations made, including the proposal to adopt 45,000 volts (declared pressure) as the intermediate pressure between 30,000 and 60,000, were confirmed. The French suggestion that 120,000 volts, 150,000 volts and 220,000 volts should be the next stages was briefly discussed, and referred to the National Committees but without a specific recommendation. A most interesting point was brought forward by Mr. Doane (U.S.A.) regarding the low pressures for electric lighting, stating that a pressure in the neighbourhood of 110 volts or 115 volts was becoming a necessity from experience in the economic production of light.

The detailed work in regard to overhead transmission was not sufficiently advanced for more than a general exchange of views, but it was agreed to ask the Belgian Committee, who had taken a most prominent part in the question of regulations for overload transmission, to bring forward for consideration a skeleton set of rules which might be adopted as a guide for all countries.

A meeting of the Advisory Committee on Screw Lamps, Caps and Holders was also held, and was presided over by Dr. Mailloux. This is the first occasion on which the manufacturers of lamp-holders in the different nations have come together under the same roof. The ground had been fully prepared by M. Zetter (Paris) and Mr. S. W. Attwell (Great Britain), and also by the Americans, and as a result of an exhaustive review of the situation, the proposal of Mr. Doaner (U.S.A.) that the lamp-holder should first be standardised, rather than the lamp cap, was agreed to, and proposals in full detail are to be drawn up in consultation with the experts in the various works manufacturing the lamp-holders, and to be put forward at an early date. The difficulties in the way of accomplishing this much desired object do not seem so insuperable as had previously appeared, and there is every reason to look forward to an early solution of this problem of such importance to the progress of the electric lighting industry.

NEW POWER STATION AT LEICESTER.

The demand for electric power in Leicester has increased to such an extent as to overtax the capacity of the two old stations, and to meet the conditions of the immediate future, as well as to provide further facilities for extension, the Electricity Committee obtained the necessary powers for the erection of a new power station. The corporation sought the assistance of Mr. C. H. Wordingham, in 1917, in the preparation of a scheme for a new power station, but the conditions prevailing at the end of, and in the years following, the war, prevented the realisation of the proposals then suggested. Since then Mr. T. R. Smith, M.I.E.E., the city electrical engineer, has made a study of modern power stations in America and later designed the new station erected on the site suggested by Mr. Wordingham. The buildings, which are situated on the Freeman's Meadow, Aylestone, were recently completed, the first power set installed, and the station was formally opened by Alderman Flint, the chairman of the Leicester Electricity Committee, on Friday, the 8th inst.

The station is built upon the right bank of the River Soar, and is beside the main line of the Midland Railway. Coal may be delivered by rail or river and the water is also available for cooling purposes. The ground is well above the flood level and has a subsoil of gravel on a bed of shale rock, which forms a good foundation for buildings and plant. The main contract, including the buildings, the turbo-alternators, electrical auxiliary machinery, the switch gear and the civil engineering work, was carried out by the English Electric Company, Limited. The other contractors were Babcock and Wilcox, Limited, who supplied the boiler-house equipment and the whole of the pipe work, and the Mitchell Conveyor and Transporter Company, Limited, who constructed the coal and ash-handling plant and the wharf. The plant so far installed is a 10,000-kw. turbo-generator set with the necessary steam and auxiliary plant, but the design of the station is such that other units may be added until plant of a total capacity of 65,000 kw. is available. The circulating water is taken by an open culvert to the river and delivered into it above an old but substantial weir which runs obliquely across the river. The water passes over this in a thin film and is cooled. An intake pipe, which is 60 in. diameter, is used to take the water from the river to a screening pit from which it is pumped through the condenser. Another intake has been provided, between the main one and the weir, to deal with the water at flood levels, when there is little difference between the two sides of the weir. When this intake is used the circulating water is discharged through what in the normal arrangement is the main intake.

The coal is delivered to the site either by rail along a special siding or by river to a new ferro-concrete wharf, which is 125 ft. long and 35 ft. wide. Each wagon containing coal is run into a "Mitchell Tippler," and when the cradle is turned through a sufficient angle by a 10-h.p. electric motor the wagon load is emptied into a hopper below. The time taken to tip and right a wagon is less than 2 minutes. Coal brought by river is unloaded by a crane into railway trucks, which are sent on to the tippler. From the underground hopper a skip hoist raises the coal to the upper part of the boiler-house and distributes it by belt conveyors into the various bunkers. The coal is taken from here through automatic weighing machines to the separate boilers. The ash produced falls into hoppers through the doors of which it is directed into wagons on a railway line below.

The steam-generating plant at present installed consists of four Babcock and Wilcox boilers, each of a capacity of 45,000 lb. of steam per hour. The steam pressure is 275 lb. per square inch, and the steam is superheated to a temperature of 700 deg. F. Each boiler unit is fitted with a superheater and a steel tube economiser. There are three chain-grate stokers fitted to each boiler. When the higher grades of fuel are fired natural draught is used, but a separate forced draught fan and the necessary air ducts are provided for each boiler so that suitable draught conditions may be obtainable when low-grade fuel is being burned.

The generating unit is a 10,000-kw. impulse turbine coupled to a 6,600 volt 50-period three-phase alternator supplied with cooled air from a closed circuit air cooler installed below, and the set is provided with condenser, air and circulating pumps and other auxiliaries. The condensate is taken back to the boilers on the "closed feed" system. A Prache and Bouillon evaporating plant is part of the equipment and supplies distilled water at the rate of 3 tons per hour for the make-up feeds. The condenser, as well as its auxiliaries, was supplied by Messrs. W. H. Allen, Sons and Co., and contains 6,030 brass tubes, each 15 ft. long and of $\frac{3}{4}$ in. diameter. The circulating water is freed from suspended matter by passing it through disc-type water screens constructed by Messrs. F. W. Brackett and Co., Limited. The deposited matter falls upon a rotating screen and is elevated out of the water until it reaches the cleaning jets, where the matter is thrown into rubbish hoppers. Each unit is capable of dealing with 2,500,000 gallons of water per hour.

The whole of the high-tension switch gear is housed in a separate building, the switches being operated by relays from the control room, which is an annexe to the turbine room. The switches are arranged in separate cubicles which are each provided with a pair of iron doors in the external wall of the building, which is the only means of access. A subway between the turbine room and the switch-house, which is of ample proportions, to permit of easy working and inspection, is used to carry the cables and control wiring.

Shipments to Guatemala.—The Department of Overseas Trade has received a despatch from H.M. Consul-General at Guatemala City stating that complaint has been made of the condition in which certain goods arrived from England, which goods were not shipped by the direct route from the United Kingdom to Guatemalan ports. The British consignments alluded to were satisfactorily packed, and appear to have been roughly handled *en route*; it is, therefore, desired to bring to the notice of shippers that a direct service from the United Kingdom exists, the use of which obviates the handling of goods until they reach their destination, thus avoiding the risk of damage in the operation of transhipment.

Dyeing of Acetyl Silk.—Among the various artificial silks, the so-called silk acetate or acetyl silk approaches the natural product most closely, and it can indeed be spun out to a tenuity exceeding that of the threads produced by the silkworm. But the acetyl silk is difficult to dye; it has no affinity for the direct dyestuffs and most of the acid dye-stuffs, which have contributed so much to the popularity of cotton fabrics. The difficulty has now been overcome by the discovery of the ionamines, on which Professor A. G. Green, F.R.S., and Mr. K. A. Saunders discoursed before the Manchester Section of the Society of Dyers recently. Since silk acetate contains the acetyl radicle in the place of some hydroxyl groups, Professor Green tried basic amido compounds, easily hydrolysed, the basis of which should be sparingly soluble in water, but easily soluble in the silk, and should hence not have too high a molecular weight. Such compounds were found in the ω-sulphonic acids of amido compounds which had so far found only a very limited application in the dyeing industry. These so-called ionamines only dye the silk, but not cotton; mixed with direct cotton dyes they can hence be used for dyeing textiles of the two materials in different colours in the same bath.

Centrifugal Draining.—In experiments made last year at the Northern Polytechnic Institute, N. 7, Messrs. Thomas Drakeley and L. Martin found that the draining efficiency of a centrifugal apparatus was not improved when the speed of the basket was raised from 697 to 1,198 r.p.m. There was a slightly increased drying effect, when the speed exceeded 697 r.p.m., and that may not be unimportant; but the separation of crystal and mother liquor was not further improved, and it would therefore appear that very high basket speeds are not required for this separation. Further experiments (see *Journal of the Society of Chemical Industry*, November 15) confirm this conclusion. By draining efficiency Drakeley means the percentage of the total mother liquor which is extracted from the crystals. Using a Spratt centrifuge with a 14 in. basket, Drakeley and L. H. Williams found that efficiencies of 10·8, 70·6, 72·6, 73·5 per cent., at speeds of 100, 476, 868, 1,198 r.p.m. Thus the efficiency was only improved by about 3 per cent. when the speed was raised from 476 to 1,198 r.p.m. The packing of the crystalline mass would, of course, influence these figures, but Drakeley does not support the view of Bryson, who suggested last year that crystals would at low speed assume a cubical packing, leaving many interstices for drainage, and at high speeds a hexagonal packing would be induced reducing the voids to the utmost.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.

*Presidential Address,** by Mr. R. H. WHITELEGG.

BEARING in mind the grouping of railways that is now taking place, and that such grouping is being brought about with a view to effecting vast economies in working, it occurred to me that it might not be out of place if I were to make, as the main subject of my presidential address, a few observations on the present-day working of the locomotive department of a railway, from the commercial and financial aspect. In reviewing the subject, I shall make particular reference to the locomotive running and mileage departments, because I believe that in accordance with methods of organisation adopted in these branches of the locomotive department, economies are either effected or otherwise. Now, with regard to the particular branch of engineering with which our Institution is so closely identified, I am inclined to think that, all along, locomotive engineers, particularly those associated with the design, construction and operating of engines on the railways, have been so preoccupied in the formulating of their plans in regard to design and construction, and endeavouring to produce the best possible machine to comply with the exacting demands of the traffic department, that I fear that they have not always viewed the question sufficiently from its economic and financial standpoint. Now that point of view is brought home to them vividly with the introduction of road motor traffic and the advent of electric traction, with all the accompanying economies and advantages that are claimed for these systems.

It would appear to me that the locomotive in the precise form as we have it to-day is, in consequence of the limit in dimensions that we are allowed to go, fast approaching finality. During the past decade we have been able to give it a new lease of life by the adoption of the principle of superheating, thus increasing its power and radius of operation, but from now onward I think it is difficult to see that much more can be done in such direction. I am not, however, one of those who think that electric traction has swooped down upon us suddenly to cure all the ailments that the poor old steam locomotive may be heir to; at the same time, I am prepared to recognise that, under certain conditions, steam traction must make way for that of electric.

In the meantime, I do think that we locomotive engineers still have considerable scope for development of our pet machine, in various ways, although it may ultimately mean the sacrifice of the boiler and the substitution of internal combustion engines, or some similar combination, as the motive power. I am encouraged in this opinion when I reflect on the question of the vast amount of capital already absorbed in the present form of traction and its permanent way, and although eventually we shall probably have to bow to the inevitable, I think the demise of the present steam locomotive, by virtue of the economic question confronting the advocates of electric traction, will still be further delayed, and considerable time remains before us to go on with the development and improvement of the steam locomotive.

Again taking a broad view of the working of railways, one cannot be oblivious of the fact that the generation of haulage power in small units (and one can but look upon the steam locomotive as a miniature generating station on wheels) as compared with bulk production in central stations is economically unsound, and I think there is little doubt that were we to start all over again with our present-day knowledge of electricity, the steam locomotive as we have it to-day would hardly be considered.

In speaking of small units, I am led to think of the boom and, might I say, menace with which the railways are faced in the shape of road motor haulage, goods and passenger, which would appear under the present unfair competitive advantage to be attempting to bring our railways wellnigh to the verge of bankruptcy. Some traffic officers that I have discussed this subject with are optimistic enough to believe that this road motor competition is only of a temporary nature and one that, with adequate railway service, can soon be swept off the highways, but when one considers that the road motor takes both passengers and goods from door to door without any question of transhipment, this new form of transportation would appear, on the face of it, to have much to recommend it.

This competition is, however, on an unsound basis, as the road motor is practically running on a permanent way almost free of cost; in fact the railway companies are in the anomalous position of indirectly, as heavy ratepayers, contributing towards providing this permanent way for their competitors. Also, I think that a great many road motors are being run without proper regard to provision against on-cost, depreciation, &c., and under such circumstances, cannot exist for any length of time.

I feel fairly confident that sooner or later the present conditions under which this road motor traffic is carried on are bound to be altered, as, apart from any other fact, the highways in this country will require to be widened, unsuitable roads deviated, and the surface made strong enough. The enormous cost of these alterations obviously must, in the near future, devolve on the motor owner, and thus then, I think, will the railways obtain some relief and be placed in a more favourable position to meet what is, at the present time, very unfair competition.

Another factor that I think it is only reasonable to suppose will have an important bearing on the cost of railway working at the present time is the bringing down of the wages of the railway worker to a proper economic level. This feature alone should eventually be conducive to the reduction of rates and charges, which in turn is bound to attract traffic to the railways. I am only mentioning these facts with regard to road motor competition as leading up to show the necessity of railway locomotive engineers exercising watchfulness and care to ensure that they get every ounce of duty possible out of their locomotives engaged in traffic service.

It can, I think, be generally conceded that the locomotive department is a vital one from the point of view of both the management and the shareholders, as in accordance with the method adopted in its organisation, money can either be made or lost, and I submit that, without extreme care in supervision, no department of a railway is so likely to incur wasteful and expensive leakages. It is also equally important that in his efforts to bring about economical working, the locomotive engineer should have every support from the traffic or operating department.

I am inclined to think that sometimes in the past the locomotive department assumed, and rightly, too, that the locomotives existed for the traffic, and that it had simply to provide engines in response to demands without closely analysing the amount of revenue-earning duty such engines had performed, while the traffic department, in turn, in their efforts to obtain and handle traffic, had not so much regard to the economic operation of the engines at their disposal as to increasing the returns of their own department, whereas, on close analysis, ofttimes such traffic would probably be shown as working at a loss.

In the past, perhaps, we have not always kept in mind the necessity of carrying on our renewals and repairs on a strictly commercial basis. Unlike private firms, we have not been in competition with the open market, therefore the necessity for keeping our shops thoroughly up to date with the latest machinery, appliances and methods has not arisen, but from now onwards, seeing that a railway company's commodity, transport in all its forms, is up against keen competition, it behoves us to look very closely into our costs, not only in repairs and renewals, but also in the operation of our locomotives and rolling-stock.

It is only by the adoption of improved methods that the British railways will, in the future, be enabled to uphold the tradition and prestige that they have hitherto enjoyed from their inception. To bring such improved conditions about, it is equally important to see to it that our staffs dealing with such matters are organised to the highest degree, and so trained in their respective spheres of labour that they all along view their particular job, not only from the practical, but also from the commercial standpoint. If, as it appears, commercial instinct is required, I rather think that the training and curriculum of the railway locomotive engineer will in future require to be modified to suit the altered conditions and circumstances of the present day, and the mere serving of a practical training in a company's railway works will not be sufficient.

I may say that in my own little experience, I find that commercialism enters very markedly into the daily work of the locomotive engineer, in fact, the actual work for which he was trained has to be done more or less in odd moments, and thus my advice to embryo railway engineers is, in future, combine commercial with your practical training if you want to be successful. I am pleased to observe that on a number of our railways young men are being given a training not only in the locomotive shops, but also in the traffic and goods departments, and in this manner I think that the right sort of men will be turned out to deal with such conditions as now, and will continue to, exist, fitting them as it will for almost any post on the railway. In this connection I need hardly remind you that several of our successful general managers received at least a portion of their training in the locomotive department.

I do not wish it to be taken for granted that the outlines I am about to give of the locomotive running and mileage departments are typical, but just a brief representation of how the subject is dealt with on the particular railway company that I have the honour to serve, having in mind the necessity of providing periodical statistics to be furnished to the Ministry of Transport for publication in the Returns.

The locomotive running department on some railways is a subsidiary department under the chief mechanical engineer, whilst on others it is a separate department, and again in some instances it is merged into that of the general superintendent or operating department. There are, of coure, varying opinions regarding the control of the locomotive running department, but personally I am inclined to think that the best result is obtained by attaching such a department to that of the chief mechanical engineeer, as he being responsible for the costs of building and repairs, would probably be more likely to see to it that engines are maintained economically and run to the best advantage when in traffic service. Again, under such conditions, he should be better able to discriminate as to the type of engines to be designed to suit any particular class of traffic. The running department may be termed the operating department, as it is the one from which emanates all the arrangements and instructions regarding engine power, and supervises all the working in connection with locomotive depots. Briefly outlined, the *clientele* of a locomotive running department of a railway is generally made up, firstly, of a running superintendent, directly responsible either to the general manager, chief mechanical engineer, or, as in some few cases, to the general superintendent, in which cases he is known as the superintendent of motive power, this latter arrangement being similar to that in vogue in the United States.

The running superintendent supervises all matters appertaining to the everyday operation of locomotives in traffic and also has direct charge of all locomotive depots on the system, which depots are, of course, in turn supervised by a head foreman, or, as in the case of the large railway, a district locomotive superintendent. The running superintendent usually has both indoor and outdoor assistants, varying in number with the size of line. His office is usually at the locomotive department headquarters, and the staff therein comprises, in addition to the usual complement of clerks who deal with all correspondence relating to engine and train working, also a staff who make out the diagrams of engine workings to supply to all the locomotive depots, which workings are, of course, frequently altered and modified to suit the seasonal and fluctuating demands of the traffic department.

This is a very important part of the work. When a new time table is published, all trains shown therein must be met by engine power, as it is of the utmost importance that the maximum mileage be got out of each engine, and with it, the greatest amount of duty out of the enginemen, having regard to their 8-hour day, and further, the arrangement of suitable relief for the men, to obviate as much as possible the necessity for overtime, a feature that oftimes presents some difficulty. Unbalanced and light running of engines has also to be curtailed as much as possible.

Attached to the running department are section locomotive inspectors, whose duties are wholly directed by the running superintendent, such as investigating accidents, signalling irregularities and derailments, and other complaints that may arise, and reporting all irregularities in the working, and drawing attention to any matters coming under their notice; also a coal inspector, whose duty is to visit all collieries from which coal is supplied to the company, and to visit the locomotive depots and see that the quality of the coal is kept up to the standard. This same department also keeps a close watch and scrutiny of the coal, oil and other stores consumed by engines at the various depots. It also deals with all matters relating to accidents, derailments, signal irregularities, and attends to all inquiries which might take place in connection with cases arising therefrom, and also interview the delinquents in these cases when necessary.

Also attached to the running department are boiler inspectors whose duties are to examine all boilers and report condition and supervise any work carried on by the resident boilermakers at the depots. The examination of all firemen as to their capabilities and fitness to become a driver, and also the periodical testing of the eyesight of enginemen, are also part of its work, and so on.

As I have already stated, closely allied to the running department is that of the mileage, which also usually comes under the control of the chief mechanical engineer. Inasmuch as the accountant's department of a railway can be regarded as its barometer, regulating its financial policy relative to its receipts, in like manner the mileage department can be regarded in a similar light in relation to the locomotive running department. The mileage department is one purely of a statistical nature, and is presided over by a chief clerk, who must be an expert in his particular business, and controls a staff of clerks also experienced in work of this character.

The publication of the railway statistics by the Ministry of Transport has, I imagine, been done with a view to placing before railway officers and the interested public a true index of the relative figures showing tabulated results of working of the several railways. Up to a certain point the tabulated figures of each company, when put in abstract form, may be comparable and indeed interesting, but before one can place absolute reliance upon such figures in making comparisons of one company with another, a very complete knowledge of the local conditions governing the working of any one railway and the nature of its traffic requires to be known before such figures can be treated as of any great value.

One useful purpose, however, is served by the publication, and that is, that every railway company is now bound to tabulate and supply such statistics on exactly the same basis and to the same formula, and I think that, generally, it tends to efficiency.

I do not propose to take up your time in describing the *modus operandi* in keeping all the mileage statistics prior to the advent of the Ministry of Transport, suffice it to say that the railway companies at the present time not only have to tabulate and keep the same information as hitherto, but a good deal more. The following is a list of the Returns that have to be furnished to the Ministry of Transport monthly, so far as the Glasgow and South Western Railway is concerned, and I think you will gather from the titles that there is a considerable amount of labour involved in their preparation.

(1) Showing the miles run by the Glasgow and South-Western Railway Company's engines over the Glasgow and South Western Railway system and all other companies' lines over which they operate.

(2) The hours in relation thereto.

(3) Showing the miles run by Glasgow and South-Western Railway Company's engines and other companies' engines over lines owned, or partly owned, by Glasgow and South-Western Railway Company, in relation to net-ton miles.

(4) The hours in relation thereto.

(5) Steam locomotives available, and in use, showing the stock at the end of the month and the percentages applicable.

(6) Showing the miles run under the headings of "passenger" and "freight" services, and also shunting by "shunting engines," coal consumed (in pounds per mile), lubricating oil used (in pints per 100 miles) in connection therewith.

Statements are made up and furnished each month

* Delivered at the opening of the 1922–23 Session. Abridged.

to the Portpatrick and Wigtownshire Joint, Caledonian, North British, North-Eastern, Midland, London and North-Western, and Maryport and Carlisle Railways, all of which the Glasgow and South-Western Railway run over or have intercommunication with, showing the miles run and time engaged by Glasgow and South-Western engines over lines owned, or partly owned, by these companies in relation to net-ton miles, to enable these above-mentioned companies to complete forms (3) and (4), which they in turn have to furnish the Ministry.

During the months of February and September, supplementary statements showing the light miles run and hours in relation thereto by purely shunting engines have to be tabulated and returned to the Ministry. Although all this information may not sound very interesting, I merely mention it to illustrate the amount of work entailed in enabling us railway officials to keep a close check on the operation and costs of working our locomotives.

I have before stated that, in many cases, it is futile to compare one railway with another, as different results are produced by different combination of circumstances, and while that is so, comparisons may assist us in adopting methods that will be conducive to bringing about efficiency and economy, which, of course, in these days is so necessary.

Considering the published statistics it will be seen that the percentage of miles run with loaded trains is, in a number of cases, practically the same. In the English group, the outstanding difference to be seen is that of the North Staffordshire Railway and the London, Brighton and South Coast Railway, the former company standing at 98·73 per cent., while the latter is 93·72 per cent. This difference is explained by referring to the percentage of miles run with empty carriages. The London, Brighton and South Coast turns out at 6·27 per cent., while the North Staffordshire proportion is 1·27 per cent., being a difference of 5 per cent. I may say that, without local knowledge, it is not easy for one to ascribe the reason for such variation, but I think very probably that some of it can be accounted for by the particular location of the carriage sidings or depots relative to the terminal station, or it may be due to trips made with empty carriage trains after having made special trips with full passenger trains. If means could be devised to dispense with the empty coach trains to some extent, a considerable saving in engine power could be effected and locomotives more profitably utilised. This is a problem, however, that does not come under our province as engineers to solve, and while it is admitted that it is difficult of solution, it is certainly a matter which should be faced.

Regarding the miles run with brake van, this item presents a very low percentage, and does not call for any particular explanation, but I may tell you that it is due to occasional circumstances, as, for instance, where we, the Glasgow and South-Western Company, run special horse-box or perhaps theatrical scenery trains on to the Caledonian or North British Railways, and our engine returns with the brake van after delivery of the loaded vehicles.

Still dealing with the coaching section, we will now turn our attention to what is termed the unproductive mileage, and which embraces the following: (1) Shunting performed by shunting engines; (2) shunting performed by train engines; (3) assisting required; (4) assisting not required; (5) light miles.

Before going further, I would just explain that in the compilation of our mileage statistics we allow 5 m.p.h. for all shunting, and for all miles incurred by ballast trains in connection with the maintenance of permanent way 8 m.p.h. is allowed. Also the term "assisting" refers to the use of a second or pilot engine on a train.

As regards shunting engine miles per 100 train-miles, that is, engines that perform no work other than the shunting of carriage trains, we find that while some companies come very near each other, in others there is a marked disparity. In the English group we will take the highest and lowest, and the same in the Scotch group. In the former, for every 100 train-miles run of the North-Eastern Company, 7·73 shunting miles were performed by shunting engines, while the Taff Vale's proportion stands at 0·91 mile. In the latter group, we find that the Glasgow and South-Western Railway stands at 8·72 and the Caledonian at 4·69 miles. The inference to be drawn here is that the North-Eastern and Glasgow and South-Western Railway Companies have more time occupied by shunting engines in making up trains and disposing of them than have the Taff Vale and Caledonian Companies. When considering train engine shunting miles per 100 train-miles, we find that this inference is to a great extent confirmed. Here we see that for every 100 train-miles run the North-Eastern stands at 0·06, while the Taff Vale stands at 7·15 miles; similarly the Glasgow and South-Western stands at 1·81 and the Caledonian at 5·39.

The time occupied in connection with shunting operations is a very important factor, and a close scrutiny of how the time is spent by each engine should be made periodically, in order to minimise the time they are kept standing idle, for example, while other trains are in the yard at work attaching or detaching. Much of the time is unavoidable, but close investigation has constantly to be made to prevent such losses, and if we take the charge for a shunting engine (13*s.* 6*d.* per hour) as laid down by the Scottish Railway Companies and multiply that by the number of hours engines are not contributing anything towards revenue, such wastage might resolve itself into a considerable sum per annum.

We will now turn our attention to the third item of unproductive mileage, and one which constitutes an important factor in the working of steam locomotives, and that is, "assisting"required." As regards this, in the English section the highest (London and North-Western Railway) is 2·11 miles for every 100 train miles run, while the lowest (London, Brighton and South Coast Railway) is 0·06 mile. The deduction presented here is of a threefold nature and may be one or any of them; the first is that one company may be running more trains which exceed the load for one engine; the second, that the gradients on that system are more difficult of negotiation; and the third, that the assisting or pilot journey may be longer.

The first deduction, namely, that the assisting or piloting required is in consequence of the load being more than the capacity of one engine, is a fact that perhaps has been of use to the locomotive engineer, inasmuch as it has given him the opportunity of designing larger and more powerful locomotives, though in this connection the usual experience is that so soon as a more powerful type of locomotive is put into service, the traffic department soon make endeavours to put it out of court by increasing the load further.

In the Scottish section we have the highest at 2·11 (Caledonian Railway) and the lowest (Glasgow and South-Western) at 0·77, and the same inference could also be drawn here. It is interesting to note that the London and North-Western and the Caledonian stand exactly at the same figure. Again, as regards "assisting or piloting not required," we find that both of these companies are closely related to each other. While the figures show, with the majority of the companies concerned, a very low percentage of assisting required and not required to the total train-miles, there is, nevertheless, a problem presented, and that is—how to reduce mileage of this character in order to get more productive work out of our locomotives. This is particularly noticeable in "assisting not required," as this class of mileage is generally incurred by engines which are scheduled to work, say, a special train from one point to another, and return light, but instead of doing so are coupled to another train which may be going in the homeward direction, for the sake of convenience; or an engine may be scheduled to pilot a train, which, after completing that work, returns home coupled to another train, although the load of that train does not justify the use of a second engine, while it is necessary to get the engine over the section.

Another important factor which we have to deal with is the "light mileage." That is, mileage incurred by engines running light from the various depots to the terminal stations to join the trains they have to work, going to or returning light from a certain point before or after working a train, for which no compensating train is available, and going to or returning from a certain point before or after (as the case may be) assisting a train.

In the English section, light mileage varies from 9·05 (South Eastern and Chatham Railway) per 100 train-miles to 1·23 (North Staffordshire Railway), and in the Scottish section from 11·11 (Caledonian Railway) to 8·35 (North British Railway). Before a deduction could be arrived at here with any degree of accuracy, it would be necessary to take into consideration how the companies compare with each other in the situation of their various locomotive depots relative to the terminal stations, as a considerable amount of light mileage can be accounted for by one company having several depots a considerable distance from the starting point of trains, while another may in all cases have their depots adjacent to the stations. It might be well for this feature to be considered with a view to placing locomotive depots as near as possible to terminal and turning points.

I will now deal with the freight mileage, and I should

Fig. 1. COACHING; YEAR 1921.

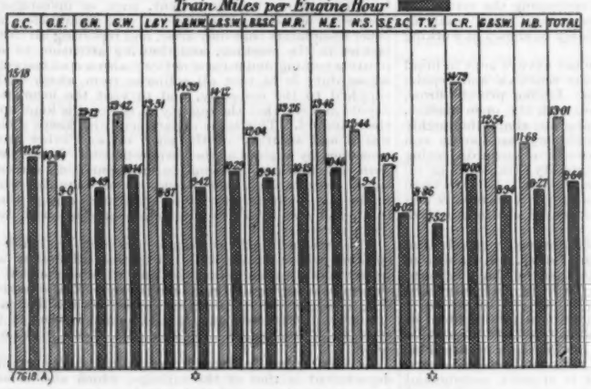


Fig. 2. FREIGHT; YEAR 1921.

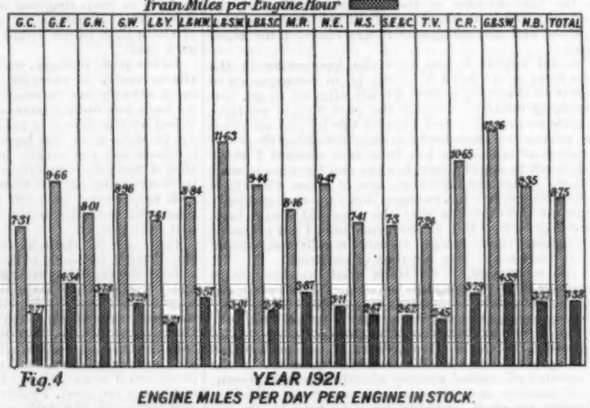


Fig. 3. YEAR 1921.
ENGINE MILES PER HOUR "IN TRAFFIC".

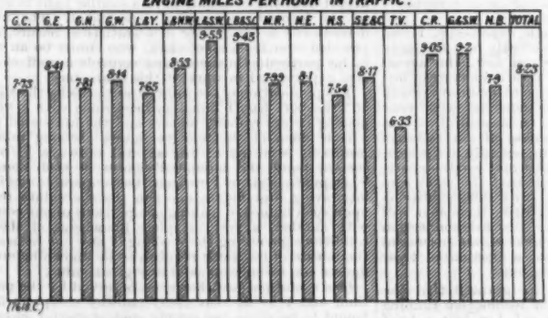
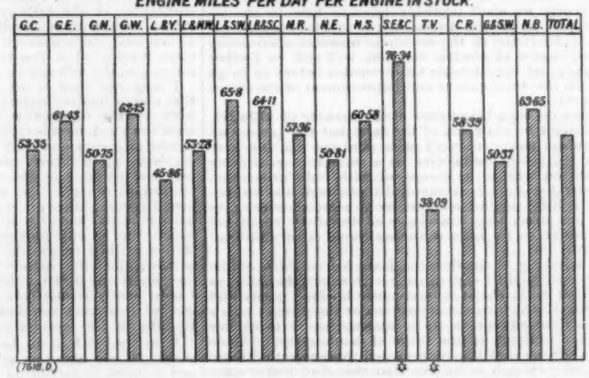


Fig. 4. YEAR 1921.
ENGINE MILES PER DAY PER ENGINE IN STOCK.



point out that in doing so, it will not be necessary to elaborate on this section to the same extent as with the coaching section. The explanations I have endeavoured to give therein generally apply to this section, but at the same time, I would like to emphasise the importance of this branch of railway working, as the mileage of this service is relative to the transit of commodities which this country is dependent on as a commercial centre. I will, therefore, confine myself to making a few general remarks on the subject.

In freight operation, we find that the empty wagon mileage and brake van mileage call for greater comment than in coaching, and this is particularly noticeable in regard to the latter class, and if you study it closely, you will see that this branch of mileage is a matter of grave importance, as it represents what may be termed items which do not produce direct revenue, although they do it indirectly, but it is those indirect items that call for improvement.

As an example, we will take the London and South-Western Railway, which shows that of the total train-miles run 1·65 per cent. represents empty wagon miles and 0·25 per cent. brake van miles, or a total of 1·90 per cent., representing indirect revenue production, while the Taff Vale Railway stands at 17·07 per cent. and 15·90 per cent. respectively, or a total of 32·97 per cent., representing the same item. In the Scotch section we find that the Caledonian stands at 5·50 per cent. and 7·33 per cent. respectively, a total of 12·83 per cent., and the Glasgow and South-Western at 3·95 per cent. and 4·40 per cent. respectively, a total of 8·35 per cent. owing to the fact that wagons loaded with commodities must be marshalled in the order of calling points, so that the working of the railways will proceed smoothly, and to minimise delay. This feature will probably, in the minds of some, enforce the argument for the adoption of higher capacity wagons. It is interesting to note how the companies under review vary in regard to shunting performed by shunting engines and train engines respectively. In the former the rate varies from 34·11 in the case of the Midland to 86·79 in the case of the South-Eastern and Chatham for every 100 train-miles run, and it is apparent that the latter company has more time occupied performing shunting operations than any of the others. Here, again, it is difficult to offer criticism without knowledge of the systems referred to.

Great variation exists between the companies as regards train engine shunting per 100 train-miles, the figures for which rise from 12·50 (Great Eastern Railway) to 68·89 (Taff Vale Railway). While the shunting operations performed by shunting engines exceed those performed by train engines from 5 miles to 61 miles in the case of the Caledonian and South-Eastern and Chatham, the train engines of the Taff Vale have had to perform more shunting operations than have their shunting engines. The deduction here may be that the train engines have to undertake work for which a shunting engine is not available, due to the distance the depot may be situated from the marshalling yards, and it is considered more judicious to employ a train engine which would be calling there.

Regarding "assisting required," this item is generally higher than in the coaching section, consequent on the heavier traffic that has to be contended with, and we here see that there is considerable variation, rising in the case of the Great Eastern from 0·02 to 14·05 in the case of the South-Eastern and Chatham, which apparently has been called upon to perform more of this kind of work than the other companies. It will suffice to say that my remarks in regard to work of this nature, as it applied to the coaching, also applies here, both in regard to "assisting required and not required" and light miles.

There is one class of mileage which has not yet been touched on, and that is departmental and miscellaneous. Under the former heading is classified all mileage incurred in connection with the locomotive, carriage and wagon, stores and engineer's departments, while all other mileage incurred which cannot be classified under any of the headings already mentioned here is brought under the latter classification. In the percentage these two classes combined bear to the grand total engine-miles the Great Northern stands highest with 5·08 in this respect, while the lowest is North Staffordshire with 1·18.

We will all be agreed on one point, that to arrive at the cost of production one of the most important "elements" which we have, or should have to take into account, is that of the "time" spent in performing the various operations. While the accepted basis of computing the unit of operating costs of a railway is per ton-mile and per train-mile, this important "element" should always be kept in view. A study of Fig. 1 shows that for every train-hour the engines are occupied they run from 8·86 miles (Taff Vale Railway) per train-hour to 15·18 miles (Great Central Railway). To arrive at a deduction in this respect the character of trains run would require to be taken into consideration; while an engine working an express train will show more miles per hour, an engine working a local train will show less. At the same time, the distance between each stop in the case of the latter requires to be taken into account, as a local train whose calling points are a considerable distance apart compared with another where the distance is less, the train-miles per hour would be appreciably affected.

Another point which calls for consideration is the time that the engines are under the orders of the traffic department, and during which period no mileage is incurred; for instance, an engine joining the train it is scheduled to work, and through circumstances which at times crop up, not getting away with the train at the scheduled time, the time thus occupied is a charge under this category and also affects the ratio of train-miles to the train-hour.

Examining this figure further, it is seen that there is considerable difference between the train-miles per train-hour and the train-miles per engine-hour in quite a number of instances. While the London and North-Western stands at 14·39 and 9·42 respectively, the Taff Vale shows the least difference, 8·86 and 7·52 respectively. It should be understood, however, that the train-hour differs from the engine-hour, as during the latter period the engines may be engaged on different operations which do not come under the heading of the former, such as running light to and from locomotive depots, shunting at wayside stations, and detention on the journey.

What I said with regard to how each company is situated in respect of depots between terminal stations applies here, and the points already mentioned would require to be carefully analysed before an accurate deduction could be arrived at.

What has been said in regard to Fig. 1 applies also to Fig. 2, with the exception that the ratio per train-hour and engine-hour is always less in this branch, due to the difference in traffic hauled, and the greater number of calls at wayside stations, and this is seen in almost all the companies under review, with the exception of the Glasgow and South-Western, which, in so far as the train-miles per engine-hour are concerned, shows very little difference when compared with the same item on Fig. 1, namely, 12·26 and 12·54 respectively. This latter feature is explained by the fact that whilst the engines of passenger trains get a run through and thereafter are detained at terminal or turning points, engines working freight trains are detained *en route*, but do not suffer much detention at terminal or turning points.

Fig. 3 shows how the companies compare as regards engine-miles per hour in traffic, and while a number show very little variation, the outstanding features are the Taff Vale with 6·33 and the London and South-Western with 9·55 engine-miles per hour in traffic. The various reasons I have already advanced, whereby deductions may be arrived at in the case of the preceding items, apply here also, and it is not necessary to enlarge further on them.

Among the many statistics now compiled, prominence must be given to the condition of the locomotive power required to serve the railways. It is of vital importance that this be carefully attended to, and for this purpose a standardised form of compilation of stock has been instituted, enabling the chief mechanical engineer to compare the value of stock to handle traffic as compared with other railways, and also to note the variations of the locomotive power month by month, thus enabling him to speed up in his repairs and renewals, or otherwise, according to requirements of the traffic which he may have to meet.

Fig. 4 gives the miles per day per engine in stock for the various companies, and the South-Eastern and Chatham Railway comes out at the top with 76, while the Taff Vale Railway is at the bottom with 38 miles per day.

From Fig. 5 it will be seen that the North Staffordshire Railway is in the fortunate position of having as high as 86 per cent. of their engines in working order, while other railways had to meet their requirements with 68 per cent., or 18 per cent. less engine power.

As regards the average number in use compared with number in stock, Fig. 6 shows that the North British Railway Company stands highest with 68 per cent., and the Lancashire and Yorkshire at the bottom with 51 per cent., while this figure also illustrates the fact that of the engines available, there were something like, over all the railways, nearly 20 per cent. idle; the London, Brighton and South Coast standing at 29 per cent. and the Great Western Railway at 12 per cent.

From Fig. 7 it will be observed the consumption of coal for the English railways is on one line as low as about 42 lb. per engine-mile, while the highest is about 64 lb., a difference of 22 lb., and the mean stands close on 53 lb. The Scottish companies are near to 67 lb. To arrive

Fig.5. ENGINES; YEAR 1921.
AVERAGE STOCK AVAILABLE FOR USE. PERCENTAGE OF STOCK.

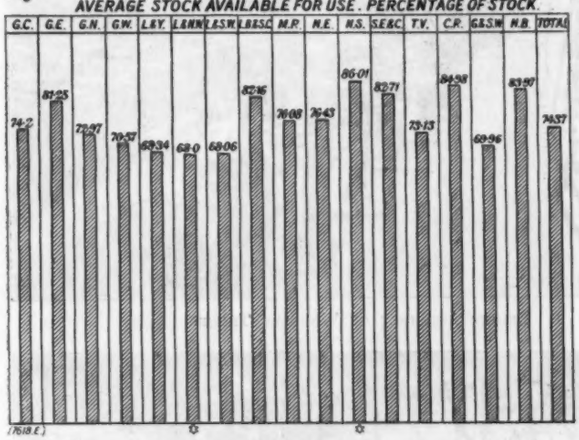


Fig.6. ENGINES; YEAR 1921.
AVERAGE NUMBER IN USE (ALL SERVICES) ON WEEK DAYS
Percentage of Stock
Percentage of Average Number Available

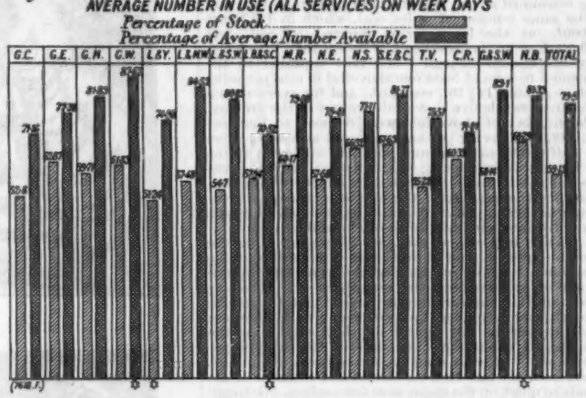
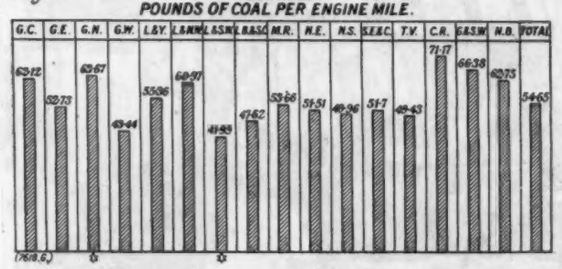


Fig.7. YEAR 1921.
POUNDS OF COAL PER ENGINE MILE.



These somewhat anomalous features are not easy to explain unless one had local knowledge of the freight working of the systems referred to. It might, however, be interesting if I quoted one of the Ministry regulations regarding the compiling of statistics of the working of freight trains, which reads: "If one or more loaded vehicles are attached to any freight train, either special or regular, at the commencement of the trip, or at any intermediate station, the whole trip to be treated as loaded train-miles."

Supposing we carry the analysis further and take the total empty wagon miles and brake van miles, both together, run by the 16 companies under review, there is found by means of apportionment, that the time spent by steam locomotives in running these miles would run up to something like 1,296,000 hours. Now, if this class of mileage had not been run, and had the engine power thus saved thereby been utilised in the service of traders against whom the present-day charge is 25*s.* per hour, this would amount to no less a sum than 1,620,000*l.* This, of course, is by way of illustration and to demonstrate to you, by the use of statistics, the necessity that exists for cutting down mileage of this kind as far as possible.

Dealing with the freight unproductive mileage, the same principles of deduction apply as they did in the case of the coaching unproductive mileage, and while, as I have already said, it is not necessary to go over again practically the same ground, I do not minimise the importance of this section, and you will see if you care to make a closer examination that a considerable number of important avenues of serious thought are opened up.

As you are all aware, shunting operations are carried on to a greater extent in this section than in the coaching,

at a true index of this difference would require a vast amount of labour, as the necessity to explore the following items is obvious: (*a*) Quality of coal; (*b*) class of engine; (*c*) traffic hauled; (*d*) gradients, &c.

You will readily understand the necessity of strict control over this all-important commodity upon the railways, when I inform you that on 15 English railways the consumption for the year 1921 was close on 8,500,000 tons, while on 5 of the Scottish railways fully 1,500,000 tons were consumed. If it were possible by economic working to reduce the poundage per mile by only 1 lb., a saving over the 20 companies referred to would be no less a sum than 377,000*l.* per annum.

Apropos of this, I have in my experience caused some surprise to locomotive drivers when calling attention to the fact that as they were a few pounds per mile in coal consumption in excess of their fellows in the link or group that it would well pay the company to dispense with their services, as they were costing the company in the excess coal they were burning a sum equal to their yearly wages, and, of course, with such men the consumption of oil and the wear and tear follows in like proportion.

Some little while ago Mr. A. J. Hill, chief mechanical engineer of the Great Eastern Railway, drew attention to the fact that it was costing his company over 1,500,000*l.* sterling for locomotive coal, and that every ton cost 2*l.* 4*s.* 9*d.* before it was burnt in the fire-box of the locomotives, whereas in 1913 it only cost 18*s.* 2*d.* a ton. Of course we have all got some substantial relief now from such high cost of fuel.

Mr. Hill further pointed out that in 1913 it was burnt at the rate of 62 lb. per train-mile, whereas it was now being consumed at the rate of 72½ lb. per train-mile, and for the same number of miles coal, which in 1913 cost 550,000*l.*, at the later period referred to cost over 1,500,000*l.*, or an increased cost of no less than 1,000,000*l.* Truly stupendous figures. Mr. Hill appealed to the enginemen to save at least one shovelful of coal per mile, which, weighing 14½ lb., cost 3½*d.*, and for every mile a locomotive travels five shovelfuls are put in the fire-box. If the number of shovelfuls were reduced to four per mile, 312,000*l.* saving per annum would accrue, or more than half of the total amount spent on coal prior to the war. I am only quoting these figures of the Great Eastern Railway as an illustration in support of my contention for the exercise of the closest economy in combating what may appear to be trifling evidence of waste, but resolve into very big items of expenditure.

A relative importance can also be placed upon the consumption of oil, and of waste and other stores in like proportion. Railway companies are generally in the position of apportioning the quantities of lubricating oils consumed in the various services and districts month by month, and noting any fluctuations; I will, therefore, confine myself to the figures as they appear in the aggregate. I might, however, observe that the proper supervision of the oil used on locomotives is no easy matter, from the fact that its careful and economical use depends so much on the enginemen themselves. Although it may be said that in many instances the men are naturally careless and wasteful, there are many men who are prone to over-oil their engine from sheer anxiety in their effort to keep out of trouble from failure from heating.

I have sometimes thought that a considerable amount of wastage could be eliminated if some better device than the ordinary worsted trimming or syphon could be devised. As you all know, such a trimming, other than the plug trimming fitted to reciprocating parts, continues to deliver oil whether the engine is running or standing, and whilst I am aware that in many instances enginemen do remove such trimmings when standing, one cannot rely upon this being a universal practice, and again, of course, there are such trimmings on the engine that are either not accessible or there would not be sufficient time for removing them. The application of mechanical lubricators for axle boxes should prove a step towards curtailing some of this loss. One has only to examine an engine after a run, or note the amount of oil that accumulates on the ground in a running shed or the adjacent yard, to realise how little of the oil issued to an engine is actually used in effective lubrication.

It will be interesting to note that for the year in question (1921) the variation in consumption of oil varies as between the companies from 5·20 pints per 100 miles to 10·88 pints. This feature certainly does attract attention, and opens up some very interesting problems, one or two of which might be mentioned, viz.: Type of engine employed and suitability for the locality or class of work so employed, quality of oil, &c. Applying the same procedure as with coal consumption, the reduction of one pint of oil per 100 engine-miles would result in a saving of close on 97,600*l.* As I am not in possession of the average price of oil over the various companies, I have taken the price paid by the Glasgow and South-Western Company, which, I am sure, would be about the average generally and sufficient to meet the purpose intended.

FACTORY PLANNING.*

A Survey of the Systems of Shop Planning for Various Methods of Production.

By H. E. Taylor.

It is now well known that rapid production flow is desirable in any factory, and for the achievement of this end the arrangement of machine tools and shop equipment must be planned so that material to be machined and assembled may travel through the various processes and shops by the shortest route. A rapid flow is also essential if the value of material in progress is to be kept down to a reasonable figure. To obtain this result very careful planning is necessary, and it is the intention of the author broadly to outline in this paper the various systems of laying out an engineering factory and to indicate the type of manufacture for which a given arrangement is suitable.

The ultimate aim of any lay-out is to obtain the product within suitable limits of finish and efficiency at the least possible cost. Given a certain piece of mechanism to be manufactured, it will be found, after a careful survey, that the possible methods of production are very limited.

Fig 1 Engine Assembly on Wheeled Trucks.

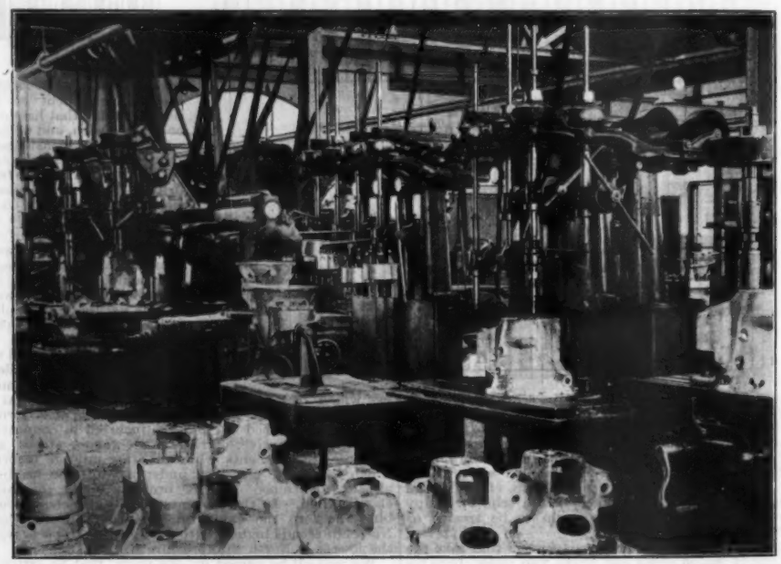


Fig. 2. Machinery Bay in Gear Shop.

Some of the many factors which determine the most suitable lay-out are: (i) Number or quantity to be manufactured; (ii) possibilities of future sales; (iii) size of the article; (iv) type of factory in which the articles are to be produced; (v) machinery at one's disposal; (vi) amount of capital available to work on, &c.

In the normal course of engineering practice it is now becoming quite common carefully to plan out a product for manufacture following design and the production of the first experimental models. The care with which this preliminary information is worked out has a very great bearing upon the efficiency of the factory, and one of the principal aims should be to arrange production so as to maintain balance in all sections.

It is interesting to know the balance and consequent efficiency of any factory or department of same, and it is possible to state this in terms of a percentage by using the formula which may be given as follows:

Let T = the actual floor to floor production times for all operations,
N = the total number of machines in the factory or department,
and W = the working hours per week,

then the balance or efficiency $= \frac{100\ T}{N W}$.

T, the production times used, should be those derived from the best results that can be developed, based on the quantity of articles to be manufactured, and the resultant figure will always be under 100 per cent.

Machining.—Suppose total actual floor to floor machining time for a complete set of engine parts is 60 hours, and production is at the rate of 120 sets of parts per week of 47 hours, and this production utilises 190 machine tools, then:

The efficiency or balance of the machine shop

$$= \frac{100\ T}{N W}$$

$$= \frac{100 \times 120 \times 60}{47 \times 190}$$

$$= 80 \text{ per cent.}$$

Assembly.—Suppose total actual times for complete assembly, including minor and major operations and incidentals, is 14 hours per unit, and production rate is 120 engines per week, occupying 38 men working a 47-hour week, then the efficiency or balance of

* Abstract of a paper read before the Institution of Production Engineers, Coventry Branch, December 5, 1922.

FACTORY PLANNING: WORKS OF THE HOTCHKISS COMPANY AT COVENTRY.

FIG. 3. GEAR-BOX ASSEMBLY ON RAISED TRACK.

assembly shop is given by

$$\frac{100\ T}{N\ W} = \frac{100 \times 120 \times 14}{38 \times 47} = 93 \text{ per cent.}$$

If sufficient consideration be exercised in planning and operating, giving due thought to the points previously enumerated, it is possible, from this information, accurately to state the number and types of machine tools required, assembly and test times, &c., and to deduce the data for floor areas, storage, transport, inspection, and, in fact, to state on paper, within a small percentage limit of error, the actual results that will be obtained.

At the present time the system of shop lay-out most generally adopted is to group machines according to type, with separate assembly shops, view rooms, stores, &c., this arrangement being most suitable when comparatively small quantities of a number of different productions are to be manufactured. In this scheme the type of small tools and gauges used are of a standard, adaptable nature, and any jigs or fixtures that may be required are of simple design.

Though a lay-out of this kind permits of great latitude in the type of articles to be produced, it nevertheless does not allow of very rapid or efficient manufacture. For instance, if an order is given for a certain number of articles to be manufactured in a factory of this description, then, should these be placed on the shop in one batch, the time taken for them to arrive at the assembly stage will be the total time of all the operations multiplied by the number to be produced. This, of course, will be a lengthy period, and as deliveries are usually an important consideration, would be a drawback. If the work were issued on to the shop in a number of small batches a certain number would reach the assembly stage at a more early date. Though there would be batches of work at each operation, and consequently the value of material in progress would be costly, this method would be an improvement on putting the work on the shop in one batch.

The most efficient way to handle work in a general shop is to decide on a suitable number for assembly, and issue work on to the machine shop in small enough batches to maintain this production, the total value of material in progress then being as small as it is possible to arrange. The dates of delivery of material to the shop should be so fixed as to maintain continuity of operations and manufacture in the various departments, otherwise time will be lost in breaking down and setting up for other jobs or in idle machine time.

A class of manufacture to which this type of lay-out is applicable is that in which the parts to be produced are small, and where the comparative value of material is not very high, in which case the grouping of machines according to type may be more economical than the line type of manufacture, and will certainly be so in the case where a very specialised plant is used, necessitating an expert in charge of each class of machine, or where changes in the design or nature of the product are likely to be made.

Variations on the grouping according to type scheme of lay-out are to sub-divide into light and heavy machine shops and assembly sections, &c., in factories where the range of productions warrant this procedure or otherwise to sub-divide the products and to group machinery according to the demands on such productions. These variations have the same fault in a lesser degree as the original system of group lay-out.

Many factories produce ranges of sizes of similar articles, and this type of production lends itself to a lay-out in which the machine tools are grouped according to the similarity of the parts to be manufactured. This method is certainly an improvement as it permits of specialisation on certain classes of work, but the amount of material carried on the shop, though less than in the preceding schemes, is still high compared with the number of articles produced. More specialised jigs, fixtures, tools, and in some cases, even special machine tools, are advisable. By breaking the machine groups up into these departments the labour is more efficient, and inspection, progress and transport are also materially assisted.

If only a moderate number of sizes of articles are to be produced, a further improvement is not only to break the lay-out according to parts, but to lay the machinery out in as near approach to operation order as is possible, compatible with the number of articles to be produced.

If only one or two productions are to be manufactured in moderately large quantities, then a great saving in time and value of material in course of progress, will be obtained by laying the machinery out in operation order for the main components, providing the quantity required is sufficient to keep them fully occupied, and to group the machinery for minor components in sections according to the type of machine. A step further forward is to then place additional other type machinery in these group departments so that certain of these details, such as bushes, shafts, &c., can be finished outright without unnecessary transport.

In a lay-out of this type quite a number of standard special-purpose machine tools, a few non-standard special-purpose machine tools, and more carefully-designed jigs, fixtures, gauges and small tools, will be required. Furthermore, it will be necessary to locate the viewers out in the sections, and stores will have to be placed in suitable positions to feed the shops constantly. A near approach to the line system of production is obtained with this type of lay-out, and it is possible to also approximate to the line system on the assembly by dividing it into minor and major assemblies.

A factory laid out on these lines will be reasonably efficient, there will be a comparatively small number of the larger and more expensive of the components actually in progress, and the value of the material of the smaller components, which will be put through in small batches, will be low compared with the total value of the finished article. As this scheme closely resembles the line system of production, supervision, progressing and clerical work are considerably reduced, a more rapid rate of manufacture of raw material into finished articles is obtained, a quicker return on the working capital is procured, and this itself can be much smaller in comparison to the total value of the productions of the factory. Broadly speaking, it is advisable to keep specialised departments such as automatic, gear cutting, hardening, &c., separated in this type of lay-out, though a certain amount of breaking up is advisable in more advanced developments.

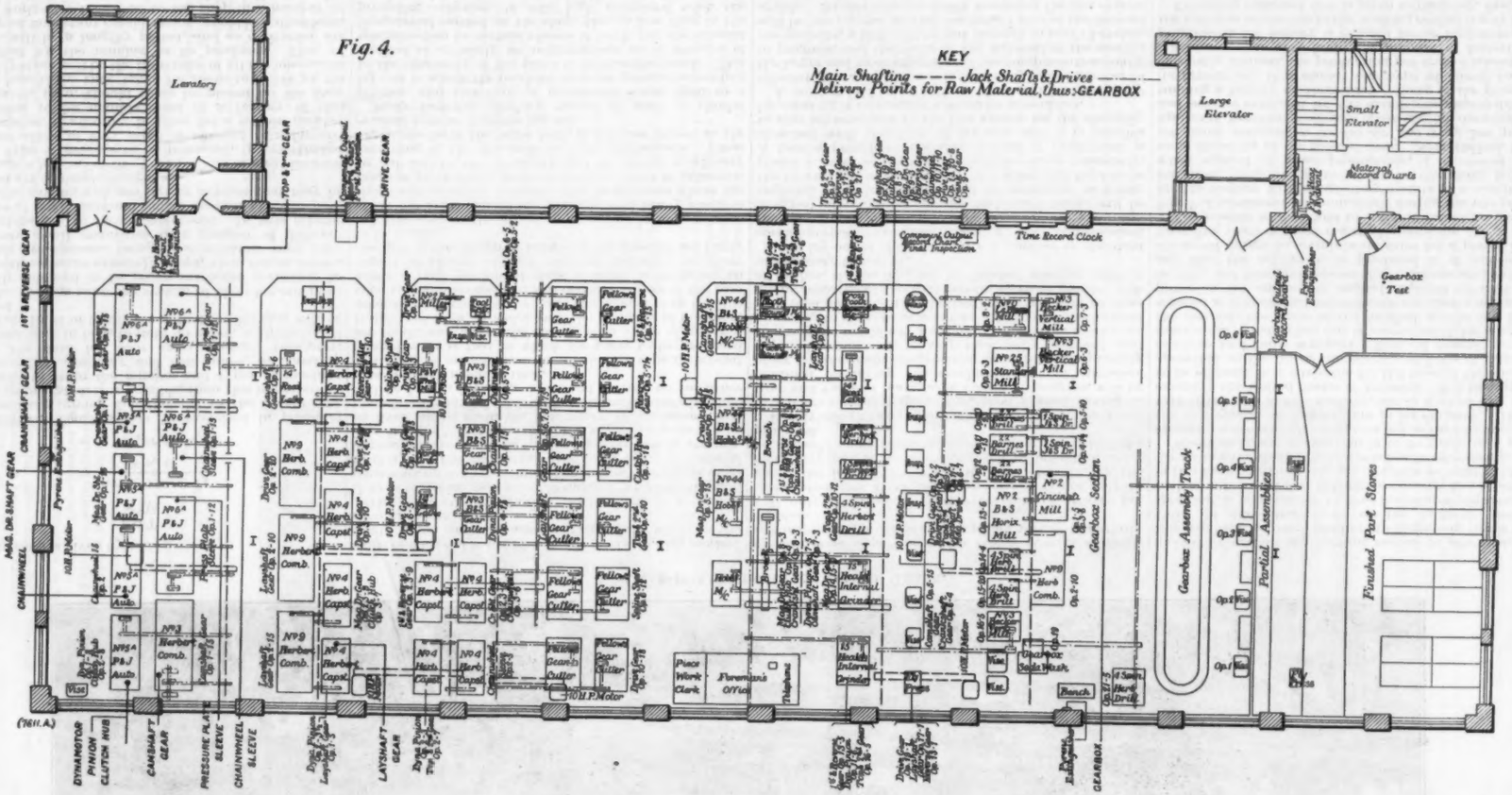
Where only one production is to be made in a given factory a more specialised lay-out can be used by adopting the line system of manufacture in its entirety. This is very little used in this country, but is worked to a large extent in the United States of America. For this system to be efficient, it is advisable for the time of the shortest operation on the minor components to keep at least one machine tool fully occupied. This, of course, necessitates a vast production, but is warranted if, by adopting the method, the price of the finished article can be so reduced as to command sufficient sales to show a reasonable profit on the amount of capital required to work the factory, and also presupposes that markets are available and that the article to be produced is of sufficiently advanced design to maintain its sales for a period of at least five years without material alteration.

The scheme was worked to a small extent on various forms of armament and munitions during the war period in this country with satisfactory results in a number of instances, but, owing to a few outstanding failures when applied to peace productions, it is viewed with some disfavour at the present time. Nevertheless, there are many features in its favour and very few points against it, providing sufficient investigation, development and care are exercised by the executives responsible for running a factory on these lines. Some of the points in its favour are, that almost any type of labour can be efficiently utilised, the production per unit of labour and machine tool is very high, the amount of material in progress on the factory is reduced to the minimum, and the turnover in relation to the working capital is very large.

Providing sufficient care is given to planning, design of machine tools, jigs, small tools, gauges, equipment, assembly, test and viewing methods, there is absolutely nothing being produced at the present time that could

FACTORY PLANNING: WORKS OF THE HOTCHKISS COMPANY AT COVENTRY.

Fig. 4.



not be manufactured to equal limits of finish and efficiency on the line system of production. Constant attention is required to maintain plant and equipment in good working order, but this can quite readily be done by organising periodic inspection of the machines, &c., as well as arranging for a percentage of more detailed inspection and test of the production. It is then possible to check back to any detail of the plant and personnel not producing to the standard required.

Almost the only further improvement that is possible is to arrange the assemblers between the machines so that machining and assembly go on simultaneously. For instance, suppose a shaft has to be fitted with keys, this could be done immediately after the keywaying operation on the shaft. If, at a later operation, a gear has to be fitted to the shaft and pinned in position, this would be done by an assembler at the point at which the shaft and gear came together. This resolves itself into the fact that all minor assemblies are to be carried out in the course of manufacture and that the major assemblies are to be carried out on a track.

The views and lay-out (Figs. 1 to 4) of the Hotchkiss Works, Coventry, illustrate some of these types of lay-outs. The factory is in three blocks, being a central five-storey steel framework building with a north factory of ground floor north lighted construction, and a south factory of similar construction.

An early lay-out which was adopted for a production of 100 engine and gear-box units per week made the best use of the existing buildings. In this lay-out the machinery for the main components was placed in sequence of operations, while the machinery for the minor components was grouped according to type, but certain other type machines were placed in these group departments so that a number of components such as pistons, crankshafts, connecting rods, camshafts, &c., could be finished outright in the group departments. The minor assemblies were carried out on benches at right angles to the main assembly lines, and the main assembly was carried out on wheeled trucks running on lines, as shown in Fig. 1, on page 756. This gave very satisfactory results as the advantages of both the grouping system and line system of lay-out were utilised.

Since the time of this original lay-out the production requirements have gone up to several hundred a week, and the lay-outs now adopted tend more toward the ideal line system. Figs. 2, 3 and 4 are photographs and a lay-out of one of the floors of the gear-box shop. In this department the raw material enters the shop at one end and passes through the department, reaching completion at the other end, where an assembly track is located.

The features of this lay-out are that though line flow is maintained, the machines needing the attention of specialists are grouped in the main according to type. For instance, all first operations on the gear blanks are carried out on chucking autos, and these machines are followed by the various types of machine tools necessary to complete the remainder of the operations on the blank, which are laid out in line order up to the gear-cutting stage, and also includes inspectors and vice stands, &c., necessary to carry out these operations, after which follows all the gear-cutting plant, which is grouped and is under the charge of a specialist. Placed beyond the gear-cutting plant is the machinery for the gear-case, which is laid out in line order with inspectors and incidental operations placed in their respective order. From this group of machinery the gear-box is immediately placed on a stand on a track upon which all the major assemblies on the gear-box are carried out. The minor assemblies are built up in a stores behind the track and are handed out through a series of hatches to the assemblers on the track.

In a further development in the engine building factory, the cylinder block, the main component, is laid out in line order down one side of the factory. The other main components such as crankshafts, camshaft, sump, &c., &c., are also laid out in line order at right angles to the cylinder block, the final operation on each reaching the cylinder block at the point at which they are to be assembled to the block. The line assembly immediately follows on the lay-out of the block, and is fed with minor assemblies from a stores placed behind the track similar to the scheme adopted for the gear-box assembly.

At a suitable point the finished gear boxes and clutches are brought in by a conveyor from the gear-box test and assembled to the engine, after which the unit passes direct into the test department, then onward for final inspection, painting, &c., to despatch.

In this lay-out the incidental operation such as hardening, sand-blasting, &c., are carried out in a basement in the centre of the shop, and the administrative offices, stores, &c., are also centralised. Except for a few of the minor components, this is a pure line lay-out, and these minor components such as bolts, studs, bushes, &c. are best handled in a specialised department equipped with grouped automatics and other suitable type machines.

(To be continued.)